取り扱い注意

調査資料２

米国政府による情報技術研究開発運営の現状と技術開発動向

－ADL社調査最終報告－

平成８年５月

財団法人　日本情報処理開発協会
先端情報技術研究所

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KEIRIN この事業は、競輪の補助金を受けて実施したものです。

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これをふるいわけ[illegible]やってみるか……

1 Funding Volume and System

1.1 Trends in Total Government R&D Spend

1.2 Estimate of Government IT R&D Spend

1.3 Outline of Funding System

IT R&D represents about 3.9% of US R&D, and is determined through a combination of top-down and bottom-up decision-making.

米国政府のIT(Information Technology;情報技術)の支出は、全研究開発支出の内約3.9%を占める。その支出の決定には、トップダウンとボトムアップの両方を組み合わせた意思決定の仕組みが使われる。

70 billionで横ばい

- Total US R&D spend has been stable at about $70 billion in recent years, although as a proportion of GDP it is declining and in real terms it is expected to decline considerably in coming years

GDP比では下がっており

実額も下がるのでは…

- IT R&D is difficult to measure precisely, but represents about 3.9% of the total, or about $2.7 billion
- The system of selecting and funding research brings together top-down 'environment-creation' and 'theme-setting' and bottom-up 'idea-generation' through two complementing approaches.

Top-Dow ↓

- environment creation
- Theme-setting

bottom-up.

- idea-generation…

1 Funding Volume and System

1.1 Trends in Total Government R&D Spend

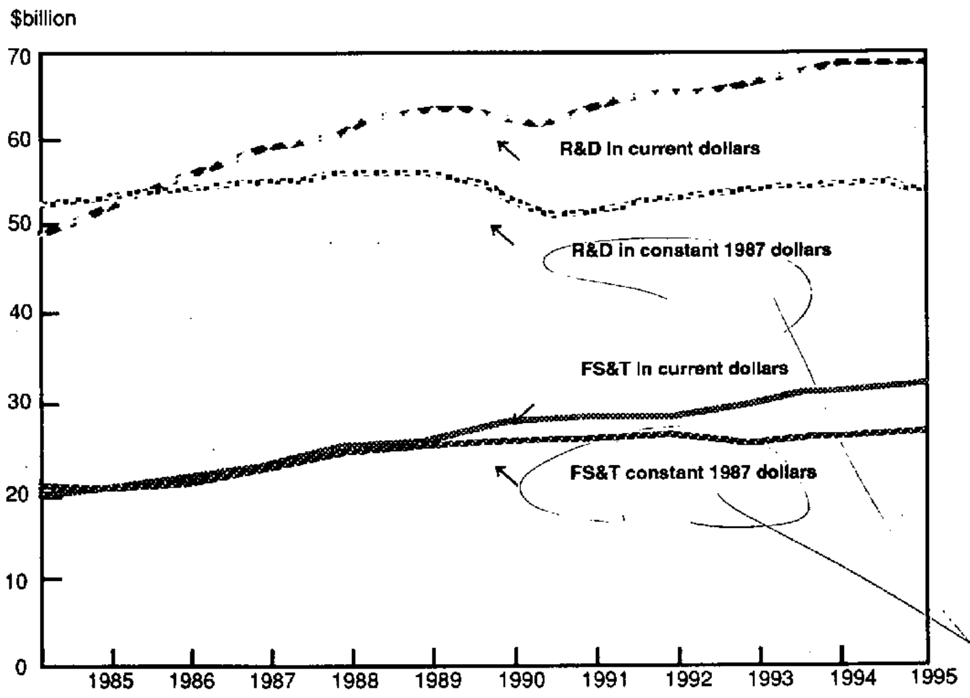
1.2 Estimate of Government IT R&D Spend

1.3 Outline of Funding System

Total US R&D spend has been stable at about $70 billion in recent years.

米国政府の研究開発総支出は、ここ数年約$700億で安定的に推移している。

10-year trend in real and nominal US R&D and FS&T spend [1]



経費計上・割り当て

- Congressional appropriation for FY 96 is likely to be around $72 billion (it will be signed into law in June)
- The Presidential Budget for FY97 requests $72.7 billion (but is usually scaled back a few hundred million dollars by Congress)[2]
- **The FS&T - (Federal Science and Technology) trend, a better indicator of government investment in new knowledge, is slowly increasing as a proportion of total R&D spend, but is static in real terms.**

意味するところが不明…

Source/Notes

1. NSF (National Science Foundation) "Federal Funds for R &D " 1995
2. "FS& T " (Federal Science and Technology) was defined in a recent report from the NAS (National Academy of Sciences) " Allocating Federal Funds for Science and Technology " 1995 as R&D expenditure, excluding federal spending on production and maintenance of weapons and space systems.

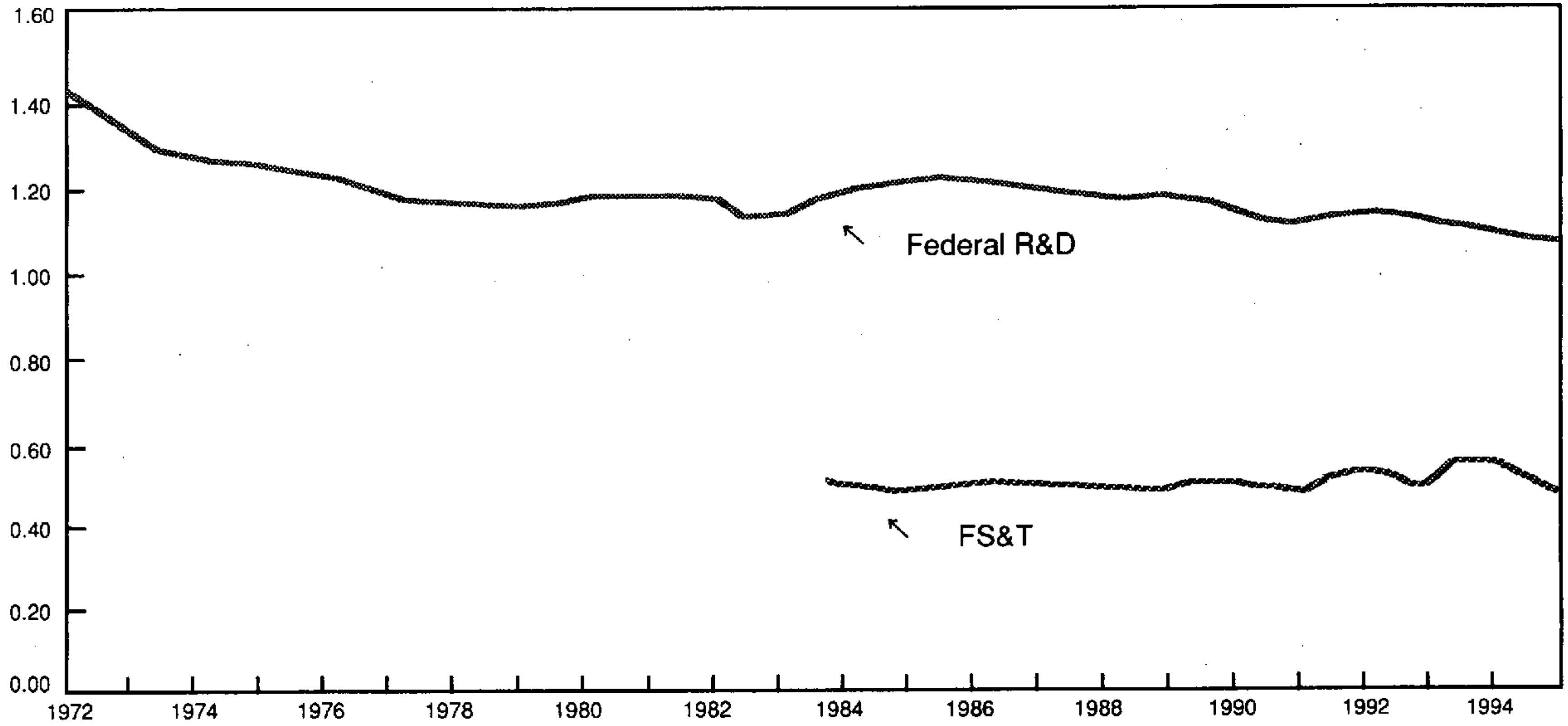
Total US Government R&D spend - as % of GDP

The decline of total R&D spend as aproportion of GDP is due to scale-backs of R&D for weapons and space systems: FS&T investment is roughly stable.

しかし対GDPとの比で見ると漸減傾向にあり、軍事及び宇宙航空分野の減少が響いていると見られる。その中でFS&T(Federal Science and Technology;政府科学技術支出)は、ほぼ一定の割合で推移している。

10-year trend in R&D and FS&T spend as % of US GDP

1.2 – 1.4 %



Source: NSF " National Patterns of R &D Resources"

In real terms total federal R&D spend is expected to decline considerably in coming years.
これから数年間に、政府研究開発予算は実質ベースで相当の減少が見込まれる。

- The recent downturn is larger than indicated in the preceding charts, since nearly $2 billion from Fiscal Year 1995 budget was subsequently rescinded. 無効になった
- The President's budget for Fiscal Year 1996 calls for cuts of about 20% in real terms over the period from 1996 - 2000.
- Congressional spending plans (outlined in the budget resolution of June 1995) call for even larger reductions of 33% in real terms by Fiscal Year 2002.
- Independent forecasts suggest federally-funded R&D could be as little as 0.26% of GDP by 2005*.

ずいぶん下回るが

- President Clinton articulated a "reasonable long-term goal" for total national R&D spend of 3% GDP (compared with 2.6% today), but did not make clear the balance between public and private contributions.

上の図では、1.2~1.3%に見えるが…

*Michael Irish, Consultant to ESI (Economic Strategy Institute)

1 Funding Volume and System

1.1 Trends in Total Government R&D Spend

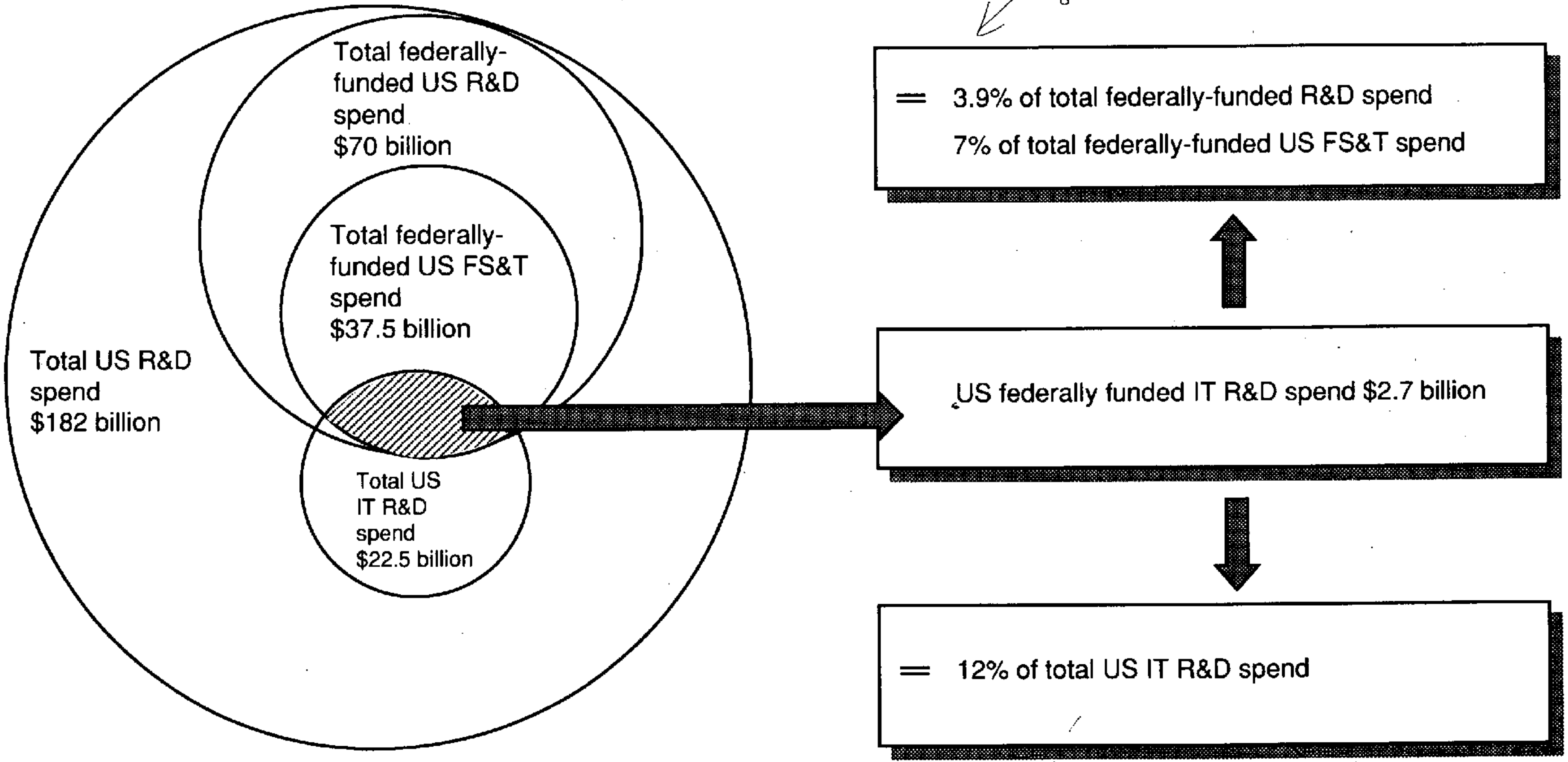
1.2 Estimate of Government IT R&D Spend

1.3 Outline of Funding System

ADL estimate of US Government IT R&D spend

ADL estimates total government IT R&D funding at about $2.7 billion per year.
ADLでは政府のIT研究開発支出を年約$27億と見積る。

まず、この図で良いのではないか!!



Total US R&D spend $182 billion

Total federally-funded US R&D spend $70 billion

Total federally-funded US FS&T spend $37.5 billion

Total US IT R&D spend $22.5 billion

= 3.9% of total federally-funded R&D spend
7% of total federally-funded US FS&T spend

US federally funded IT R&D spend $2.7 billion

= 12% of total US IT R&D spend

これは大きいのか、小さいのか!!?

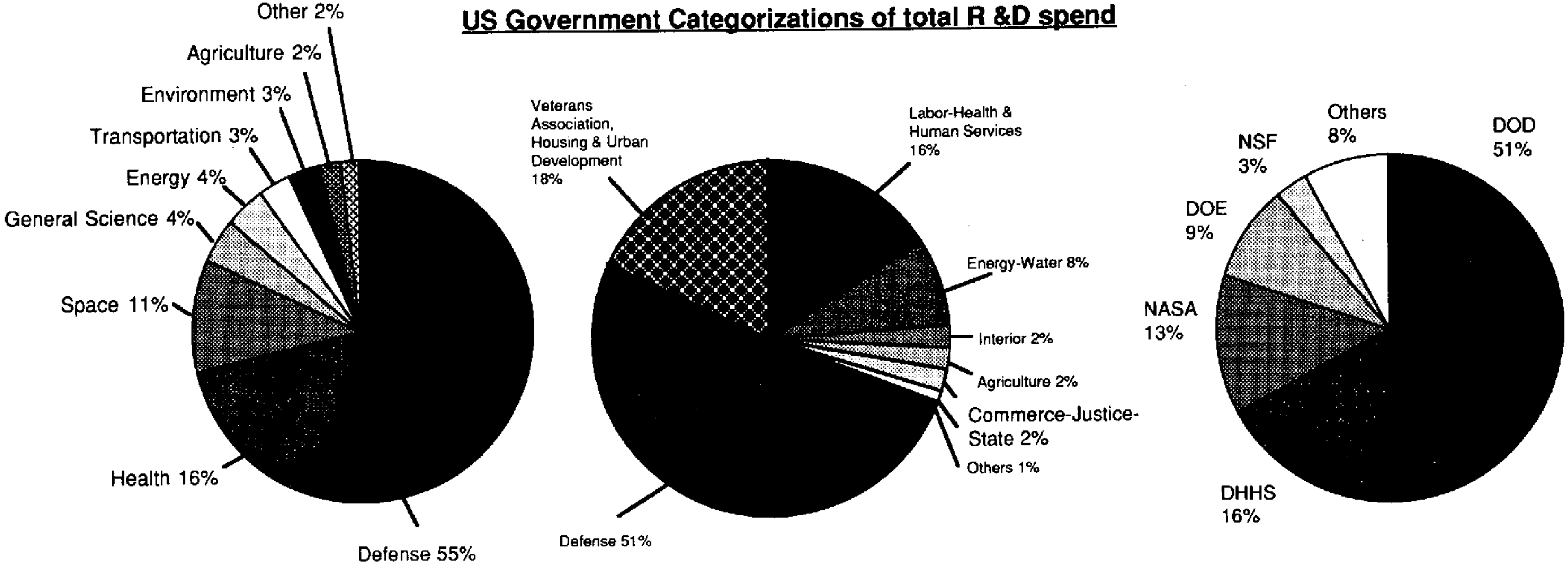
Sources
- -Battelle / R&D Magazine's 1995 Annual R&D Forecast
- -Science and Engineering Indicators 1993
- -Peter Coy, "R&D Scoreboard", Business Week, June 28, 1993, pp-102-104
- -ADL projections and calculations

ADL estimate of US Government IT R&D spend - US Government Categorization of R&D spend

Because the US government categorizes R&D spending by 'application' and by 'organization', but not by 'nature' of research, it is impossible to estimate IT R&D spend directly from government statistics.

米国政府の統計では、研究開発支出をその応用分野や出資省庁組織で細分化しており、研究開発の性質では分けていないため、ITへの研究開発支出を直接読み取ることは不可能である。

US Government Categorizations of total R &D spend



Split by 'national goal'

Split by 'appropriations subcommittee'

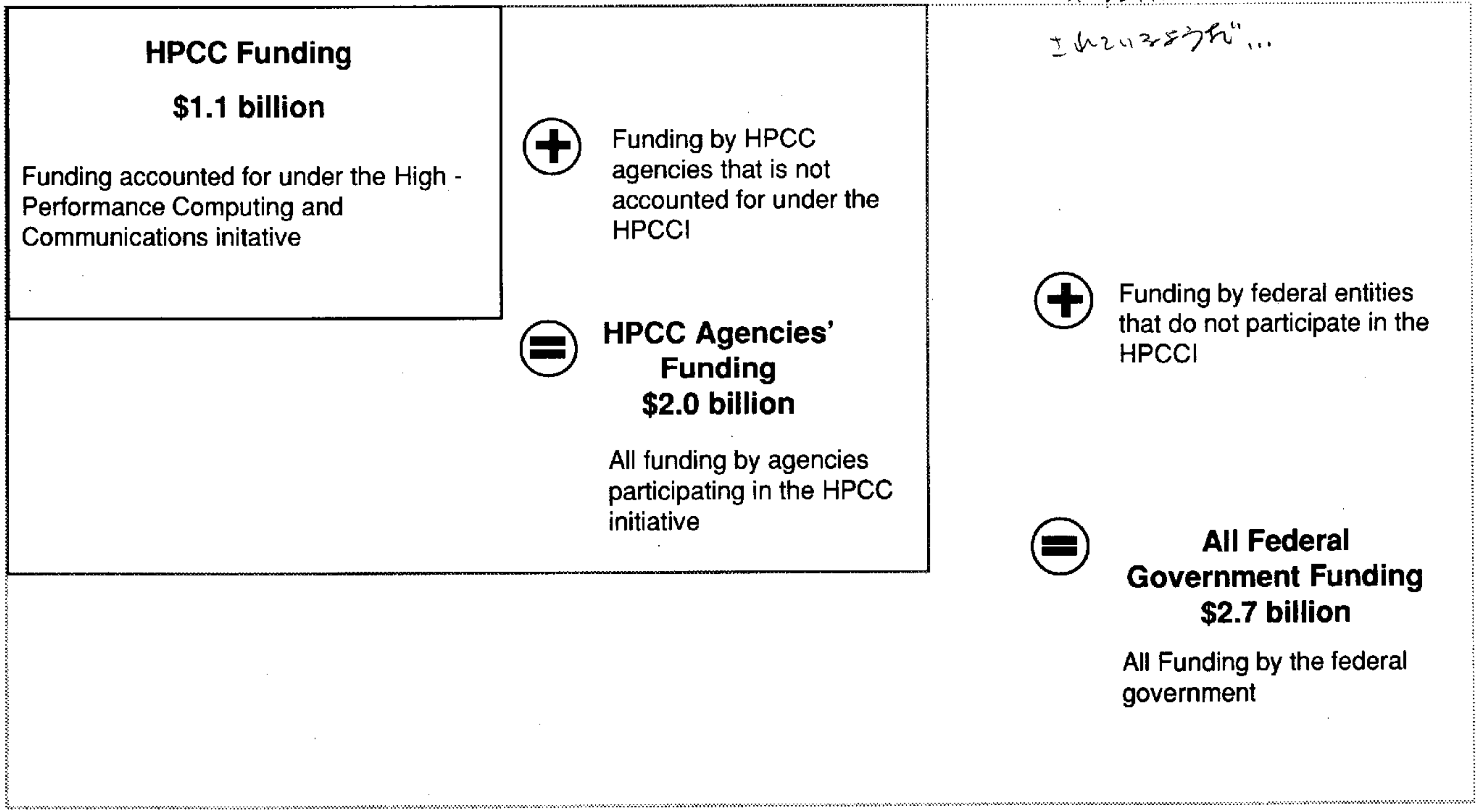
Split by 'agency'

Source: NAS (National Academy of Sciences) "Allocating Federal Funds for Science and Technology' 1995

Abbr: NSF-National Science Foundation, DOE-Department of Energy, NASA-National Aeromantics and Space Administration, DHHS-Department of Health and Human Services, DOD-Department of Defense

ADL has therefore estimated government IT R&D spend based on a three-stage process.
従ってADLではITの研究開発支出を3段階の方法で見積ることとした。

→この経緯が軽く[illegible]
されているようだ…



HPCC Funding

$1.1 billion

Funding accounted for under the High - Performance Computing and Communications initative

⊕ Funding by HPCC agencies that is not accounted for under the HPCCI

⊜ **HPCC Agencies' Funding**
$2.0 billion

All funding by agencies participating in the HPCC initiative

⊕ Funding by federal entities that do not participate in the HPCCI

⊜ **All Federal Government Funding**
$2.7 billion

All Funding by the federal government

The HPCC (High Performance Computing and Communications) Initiative is the government's principal IT-focussed coordinating body, with involvement in a large part of the IT activities of currently twelve federal agencies and departments.

HPCC(High Performance Computing and Communication)プログラムは、政府のITに関する研究開発の中心となる調整機関で、現在12の省庁でのIT研究開発がHPCCプログラムの一環として含まれる。

Research & Development Departments and Agencies over whom HPCC has involvement in some or all of IT activities (1996)

$M	%		
363	31.1	DARPA	Defense Advanced Research Projects Agency*
314	26.9	NSF	National Science Foundation
136	11.7	NASA	National Aeronautics and Space Association
124	10.6	DOE	Department of Energy
79	6.8	NIH	National Institute of Health
40	3.4	NSA	National Security Agency
34	2.9	NIST	National Institute of Standards and Technology
23	2.0	VA	Veterans' Association
17	1.5	ED	Department of Education
15	1.3	NOAA	National Oceanic and Atmospheric Administration
12	1.0	EPA	Environmental Protection Agency
9	0.8	AHCPR	Agency for Health Care Policy and Research
1166	100.0		

Top 4

Source: HPCC Program Implementation Plan FY 96

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* DARPA was originally formed as 'ARPA', the Advanced Research Projects Agency. It then became DARPA during the 1970s, but was changed back to ARPA during 1993. In March 1996 it once again became DARPA, with the passing of the Defense Appropriations Bill.

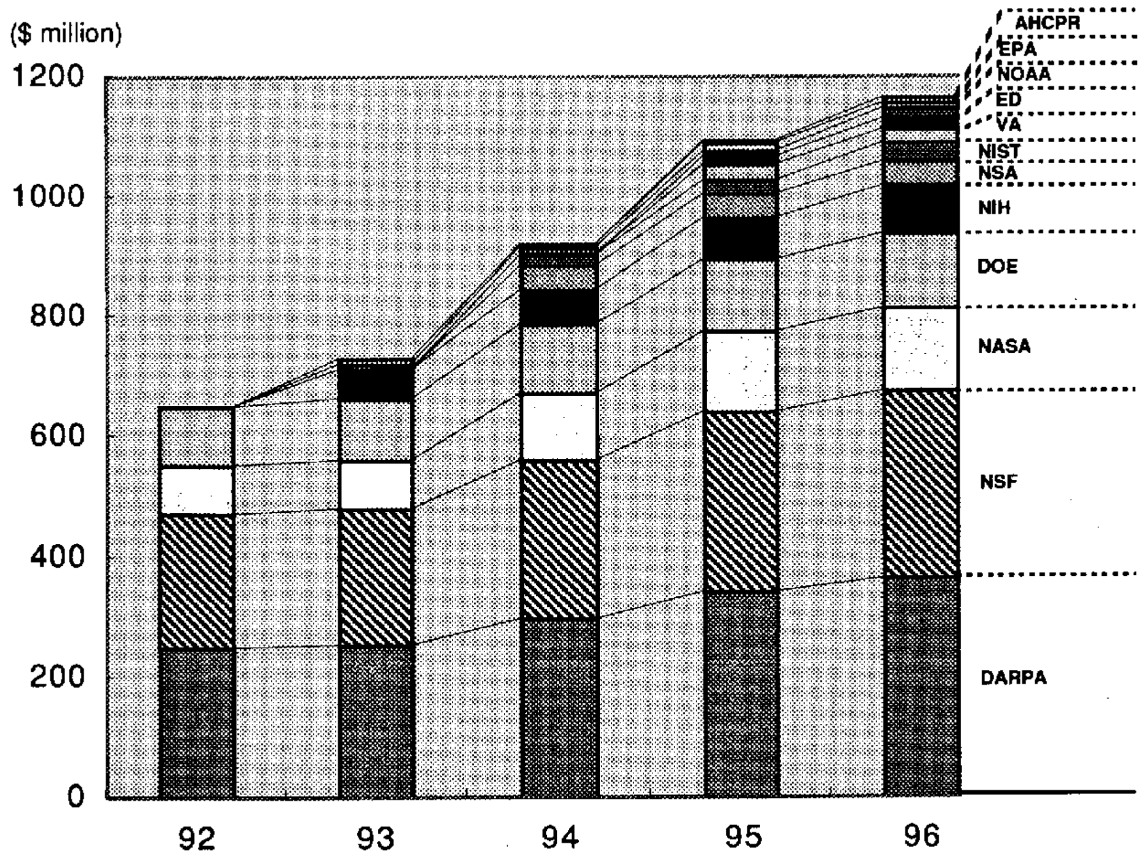
ADL estimation of US Government IT R&D spend - HPCC Funding

91時にはじまった

HPCC funding of $1,166 million in FY96 has grown dramatically since the program's inception in 1992, mainly because agencies have entered the program and reclassified their original activities.

HPCCとしての支出は92年にプログラムが始まって以来大きく伸び、96年には$11.7億にまで成長している。しかしその背景としては、各省庁が年々HPCCに参加したり、既存の研究開発活動をHPCCの一環として再分類したことが大きい。

HPCC Budget Growth since inception

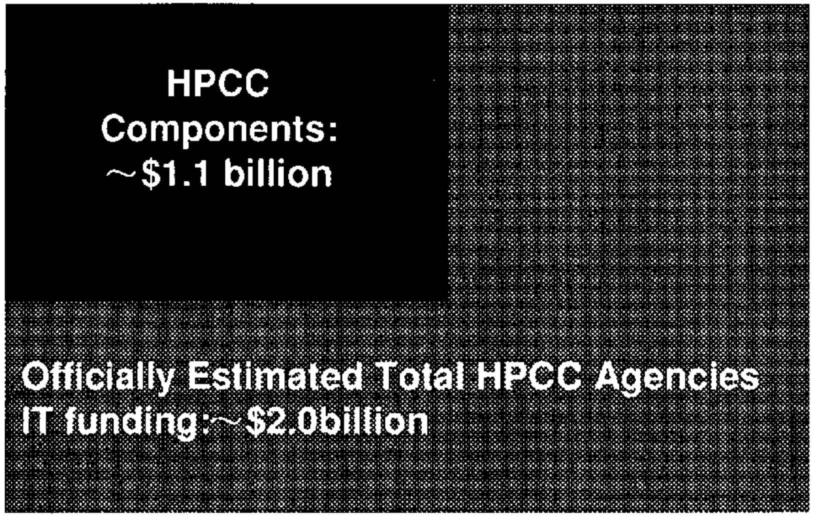


Source: HPCC Program Implementation Plans, FY94, FY95, FY96

- The Program has grown at an average rate of 15.6% per year
- However, much of that growth has been through:
  - addition of new agencies to the program by reclassification of their activities as HPCC
  - inclusion of additional activities of original agencies under HPCC banner

The federal Committee on Information and Communications has estimated the total IT R&D funding of HPCC agencies at about $2.0 billion.

政府の情報通信委員会(Committee on Information and Communications; CIC)では、HPCC参加省庁のIT研究開発支出を約$20億と見積っている。



HPCC Components: ~$1.1 billion

Officially Estimated Total HPCC Agencies IT funding:~$2.0billion

Example: Funding at NASA for a numerical aerodynamics simulation program that is outside of DARPA.

- Official estimate by the Committee on Information and Communications (CIC) of the National Science and Technology Council (NSTC)
- Covers all agencies participating in the HPCC initiative, and only these agencies
- Based on informal requests for information made to the various agencies in 1995
- ADL interviews with major agencies have confirmed this estimate

← 予算以外なのか

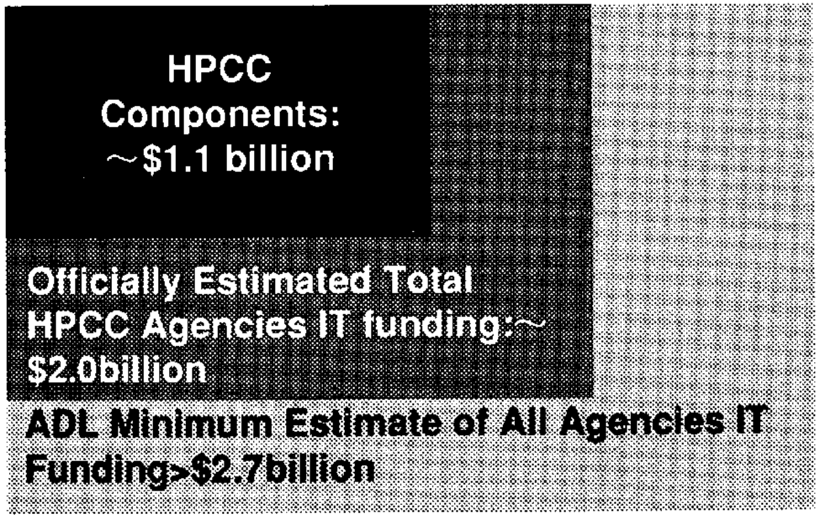
予算がついているけど計数が違うから見えないのか??

Source: personal communication with
- John Toole, co-chairman of CIC
- Paul Regan, executive secretary of CIC
- representatives of ARPA, NSF, DOE, NASA

ADL estimation of US Government IT R&D spend - Non-HPCC agencies

ADL estimates that agencies and departments that do not participate in the HPCC initiative spend at least another $700 million on IT R&D, bringing the total to $2.7 billion.

これに加え、HPCCに参加してない省庁のIT研究開発支出が少なくとも$7億あるとADLでは見積っており、政府の総IT支出は約$27億と見積られる。



HPCC Components: ～$1.1 billion

Officially Estimated Total HPCC Agencies IT funding:～ $2.0billion

ADL Minimum Estimate of All Agencies IT Funding>$2.7billion

Examples: Funding at the Department of Defense outside DARPA; Funding of the Geological survey at the Department of the Interior

- Includes estimated funding of agencies and departments which do not participate in the HPCC program
- Based on the fact that 25% of government computer sciences research obligations in FY 1993 was accounted for in such non-HPCC agencies
- Is a minimum estimate of total federal government IT R&D funding

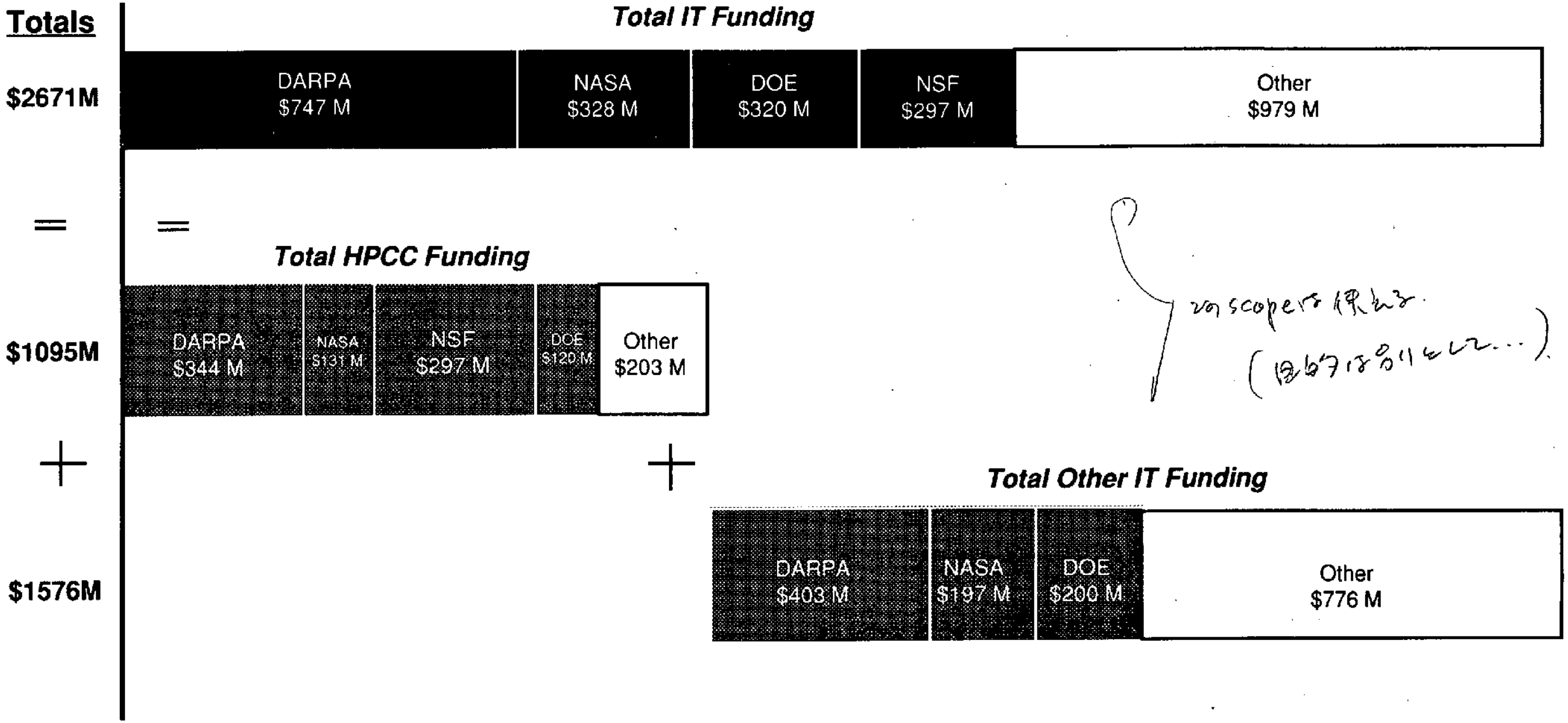
Source: NSF Survey of Federal Funds for R&D, Federal obligations for research in mathematics, computer sciences and in social sciences

ADL projections and calculations

ADL estimation of US Government IT R&D spend - Key Agencies detailed

Of the total $2.7bn, four agencies (DARPA, NASA, NSF and the DOE) account for 82% of HPCC funding* and 63% of total government IT funding.

その$27億の内、4つの省庁、即ちDARPA、NASA、NSF、DOEがHPCC支出の内82%を占め、政府総IT支出の63%を占める。



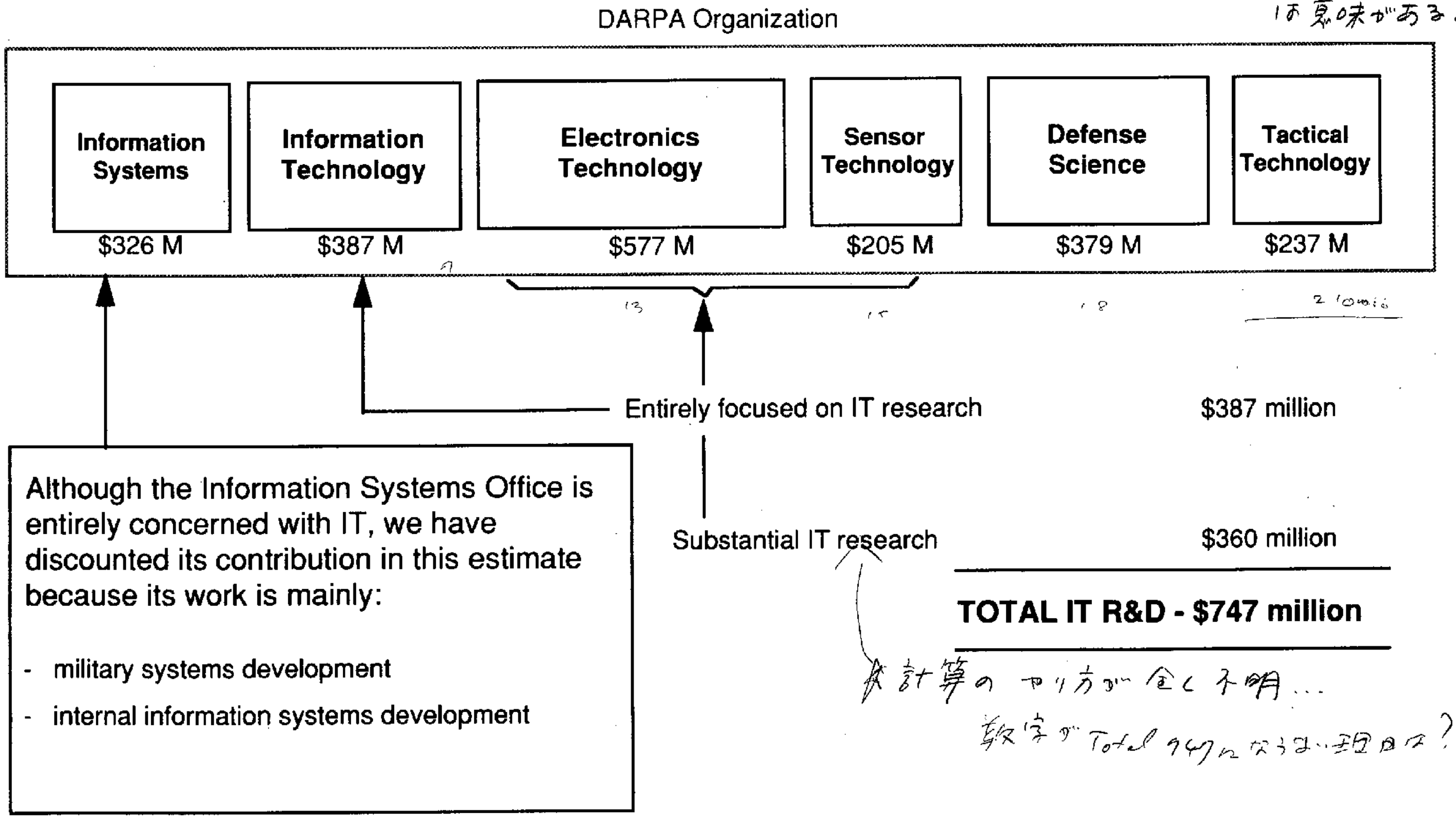
このscopeは保れる。
(国防は別として…)

***Based on 1995 figures**

ADL estimation of US Government IT R&D spend - Key Agencies detailed - DARPA

Much of the research at DARPA is related to IT, reflecting the increasing strategic importance of IT to the defense industry.
DARPAでの研究の多くの部分はITに関連しており、ITの軍事利用への戦略的重要性を反映している。

DARPAの研究として
は意味がある…



DARPA Organization

Information Systems	Information Technology	Electronics Technology	Sensor Technology	Defense Science	Tactical Technology
$326 M	$387 M	$577 M	$205 M	$379 M	$237 M
	7	13	15	18	2100mil

Entirely focused on IT research $387 million

Substantial IT research $360 million

TOTAL IT R&D - $747 million

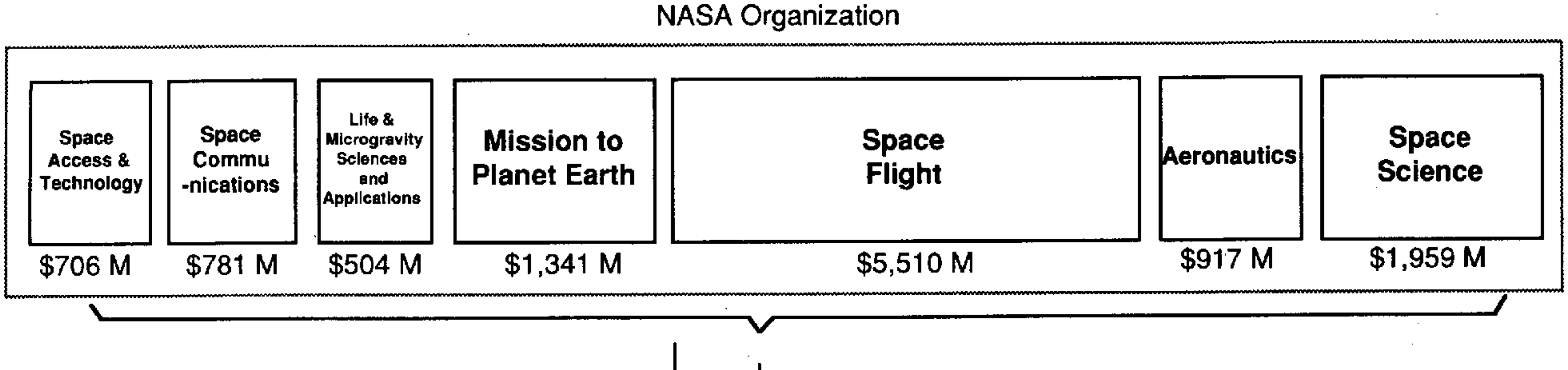
計算のやり方が全く不明…
数字がTotal 747にならない理由は?

Although the Information Systems Office is entirely concerned with IT, we have discounted its contribution in this estimate because its work is mainly:

- military systems development
- internal information systems development

ADL estimation of US Government IT R&D spend - Key Agencies detailed - NASA

NASA IT funding takes place across all divisions in roughly equal parts.
NASAでのIT支出は、全ての部門に平均的にまたがっている。



NASA Organization

Space Access & Technology	$706 M
Space Commu -nications	$781 M
Life & Microgravity Sciences and Applications	$504 M
Mission to Planet Earth	$1,341 M
Space Flight	$5,510 M
Aeronautics	$917 M
Space Science	$1,959 M

HPCC Funding	$131 million
Non-HPCC Funding (excluding space equipment development)	$197 million

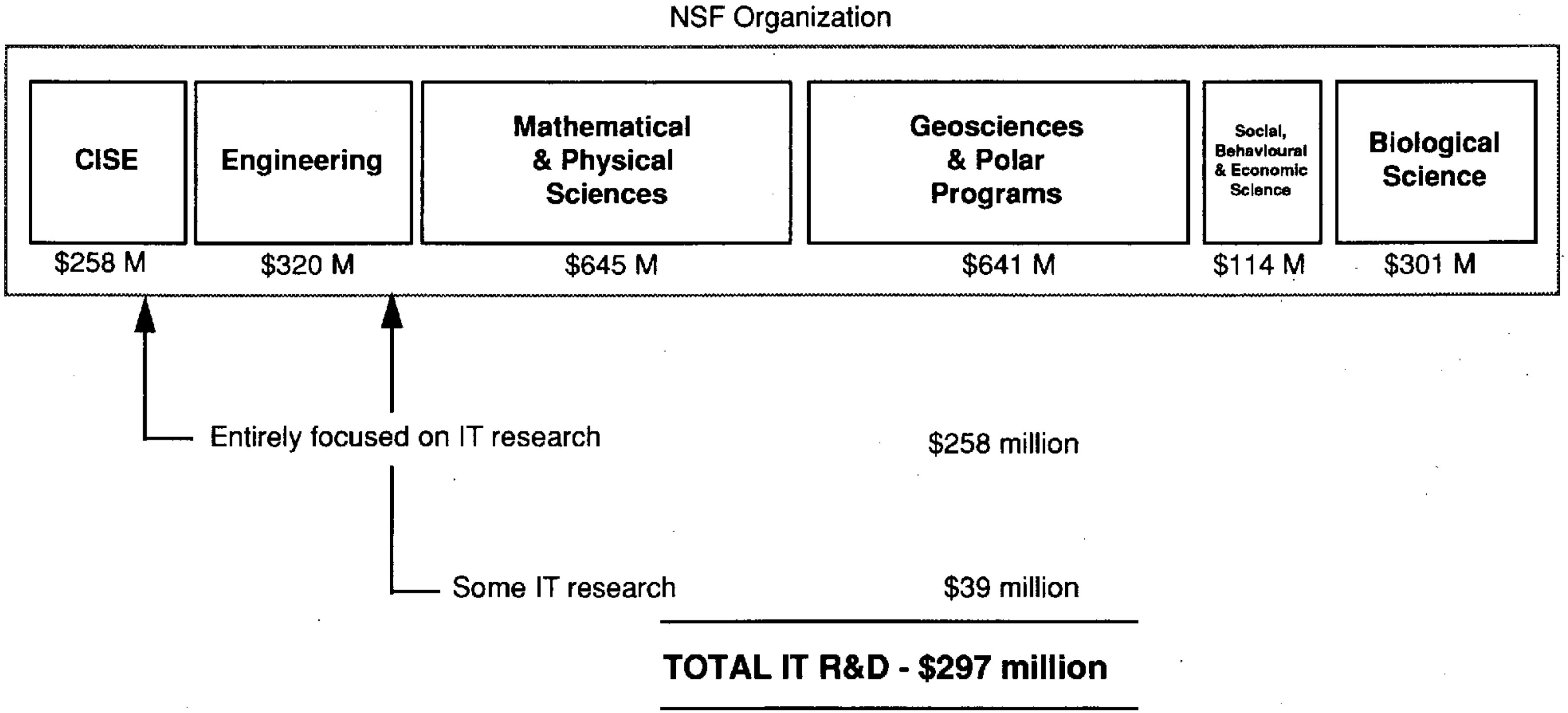
TOTAL IT R&D - $328 million

We have discounted an additional $196 million of IT systems development because it occurs in the context of space missions

ADL estimation of US Government IT R&D spend - Key Agencies detailed - NSF

IT research at the NSF is concentrated in the CISE (Computer and Information Science and Engineering) and Engineering departments

NSFでのIT支出は、CISE(Computer and Information Science and Engineering)とEngineeringの2部門に集中している。



NSF Organization

CISE	**Engineering**	**Mathematical & Physical Sciences**	**Geosciences & Polar Programs**	**Social, Behavioural & Economic Science**	**Biological Science**
$258 M	$320 M	$645 M	$641 M	$114 M	$301 M

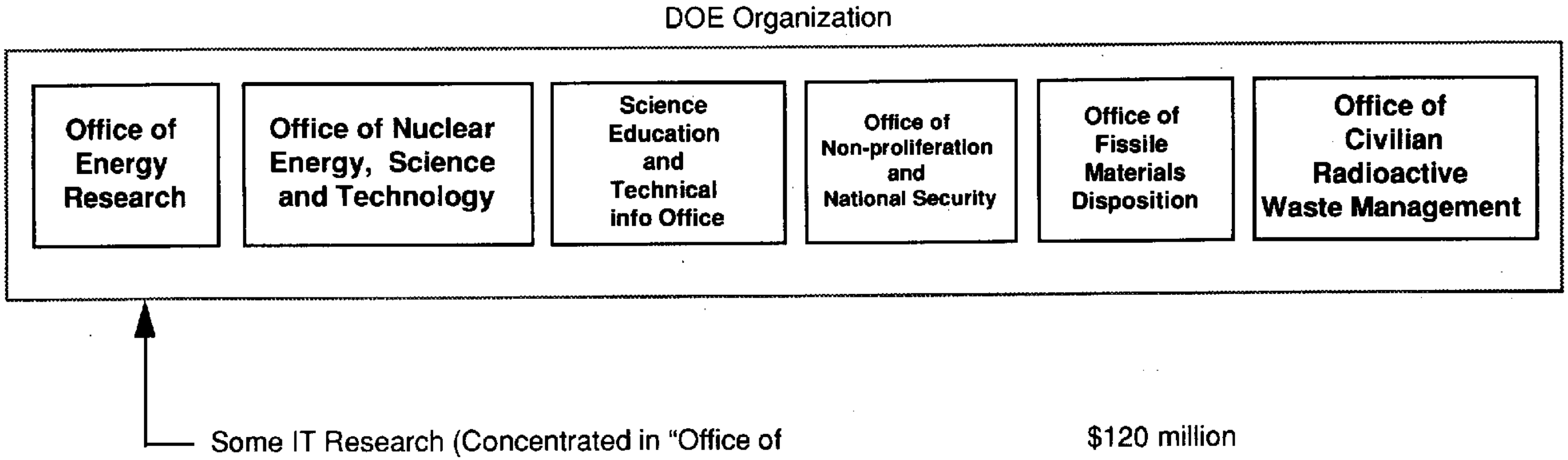
Entirely focused on IT research	$258 million
Some IT research	$39 million

TOTAL IT R&D - $297 million

ADL estimation of US Government IT R&D spend - Key Agencies detailed - DOE

DOE IT R&D is concerned primarily with applications of computers to energy research, together with some defense-related research.

DOEでのIT研究開発は、主にエネルギー研究へのコンピューターの応用と、軍事関連の研究において行われている。



DOE Organization

Office of Energy Research

Office of Nuclear Energy, Science and Technology

Science Education and Technical info Office

Office of Non-proliferation and National Security

Office of Fissile Materials Disposition

Office of Civilian Radioactive Waste Management

Some IT Research (Concentrated in "Office of Computational Technology" — $120 million

- -Super Computing $40 M
- -ES Net $13 M
- -Hardware and Software $20 M
- -Other $47 M)

Some IT Research (Concentrated in — $200 million

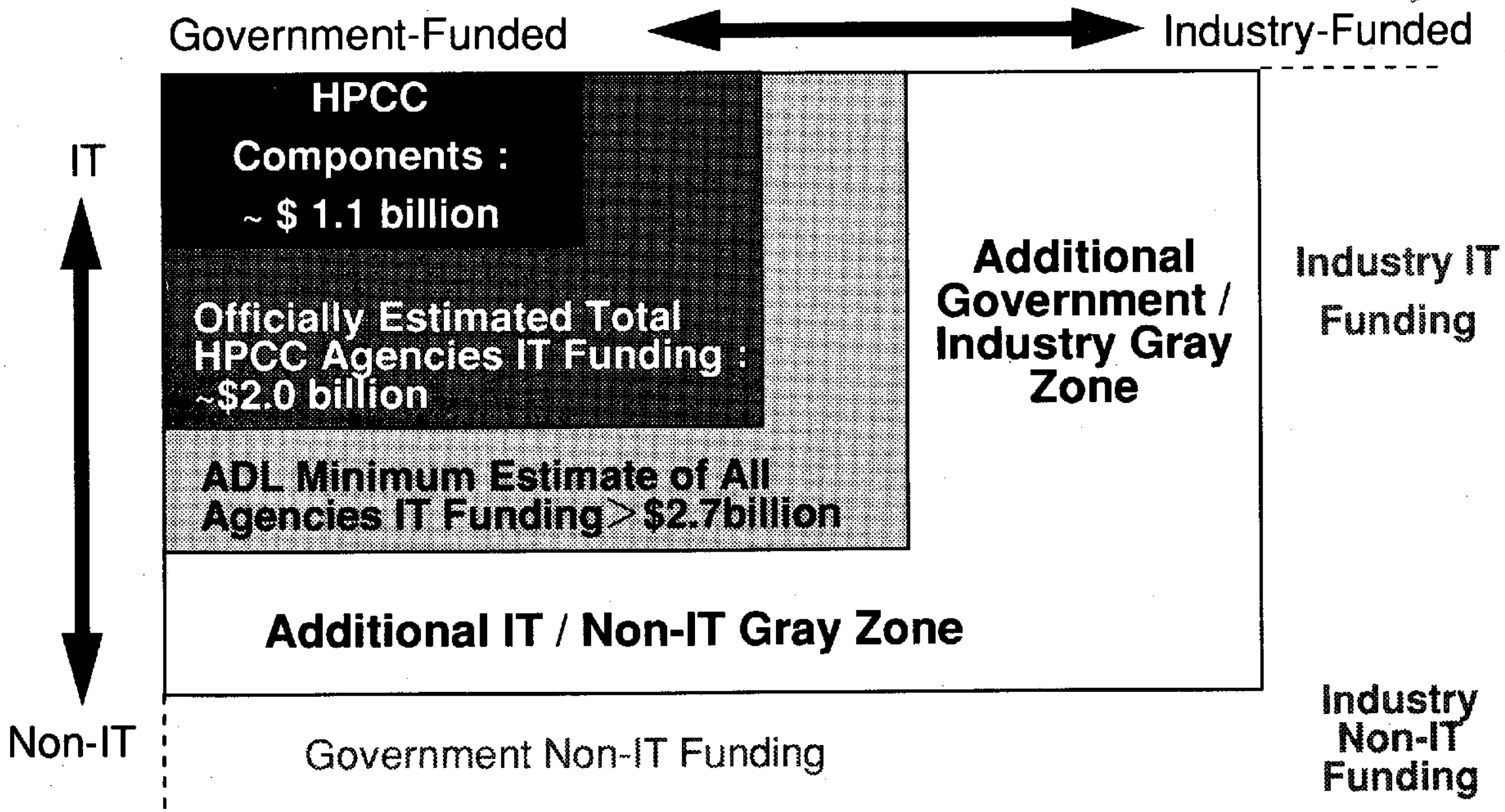
- -Core Defense Program Computing $100
- -Advanced Scientific Computing Initiative $100)

TOTAL IT R&D - $320 million

Two Additional Gray Zones

さらに、IT関連かそうでないかを明確に区別できないことによる曖昧な領域＝グレーゾーンと、一部の政府援助が企業からの資金を伴うことを条件としているために、企業と政府のどちらが分担しているかが曖昧なゾーンが存在する。

↑こんな話をいっているのが…



Government-Funded ⟷ Industry-Funded

IT ⟷ Non-IT

HPCC Components : ~ $ 1.1 billion

Officially Estimated Total HPCC Agencies IT Funding : ~$2.0 billion

ADL Minimum Estimate of All Agencies IT Funding > $2.7billion

Additional Government / Industry Gray Zone

Industry IT Funding

Additional IT / Non-IT Gray Zone

Government Non-IT Funding

Industry Non-IT Funding

↙これは当然あり得る

ADLは、これを、どうしているのか…

米国政府は投資効果を高めるために、一般企業や他のソースからの調達手段も併せて確保させるようにしており、これが政府基金と産業界からの資金との境界を曖昧にしている要因にもなっている。

- **funds with matching requirements**

  funding volume depends on the extent to which industry funds can be raised

  for example, supercomputer centers have more than 1 : 1 matching of government funds by industry funds

- **cooperative research and development agreements (CRADAs)**

  significant structure particularly for cooperation between government labs and industry

  for example, the National Institute of Standards (NIST) participates in one CRADA for about every five researchers

- **informal agreements and equipment sponsoring which are hard to track**

  equipment donations by industry

  e.g., most of the equipment in Berkeley's NOW (Network of workstations) project is contributed by industry

  exchange of personnel

  e.g., the NIST hosts 1,200 guest researchers each year

これは、人的還流の形で
お金と直接結びつかない。

IT / Non-IT Gray Zone

さらにIT領域とIT関連領域の境界にもグレーゾーンが存在する。

- **R&D funding in IT-related fields**

  problem here is the definition of " IT " and of separating IT funding from non-IT funding

  such problems occur, for example, in the areas of components

  componentがITではないというものは…

- **government funding that is not direct IT R&D funding**

  in this case, the problem is the definition of " R&D " and how to separate R&D funding from non-R&D funding

  for example, investments in computing and communications infrastructure for research

  infraは 土木とか、建築といったものが含まれる意味か??

  for, example, funding of education and training of non - IT scientists in IT topics

  (教育)

- **applications research vs fundamental IT research**

  many projects mix IT R&D funding and IT applications R&D funding

  for example, much of the computational science R&D funding goes to joint teams of IT and applications researchers

  research

  とくにいう格差がないと思うが!!…

  このあたりは、強みとして可能ではないか…

1 Funding Volume and System

1.1 Trends in Total Government R&D Spend

1.2 Estimate of Government IT R&D Spend

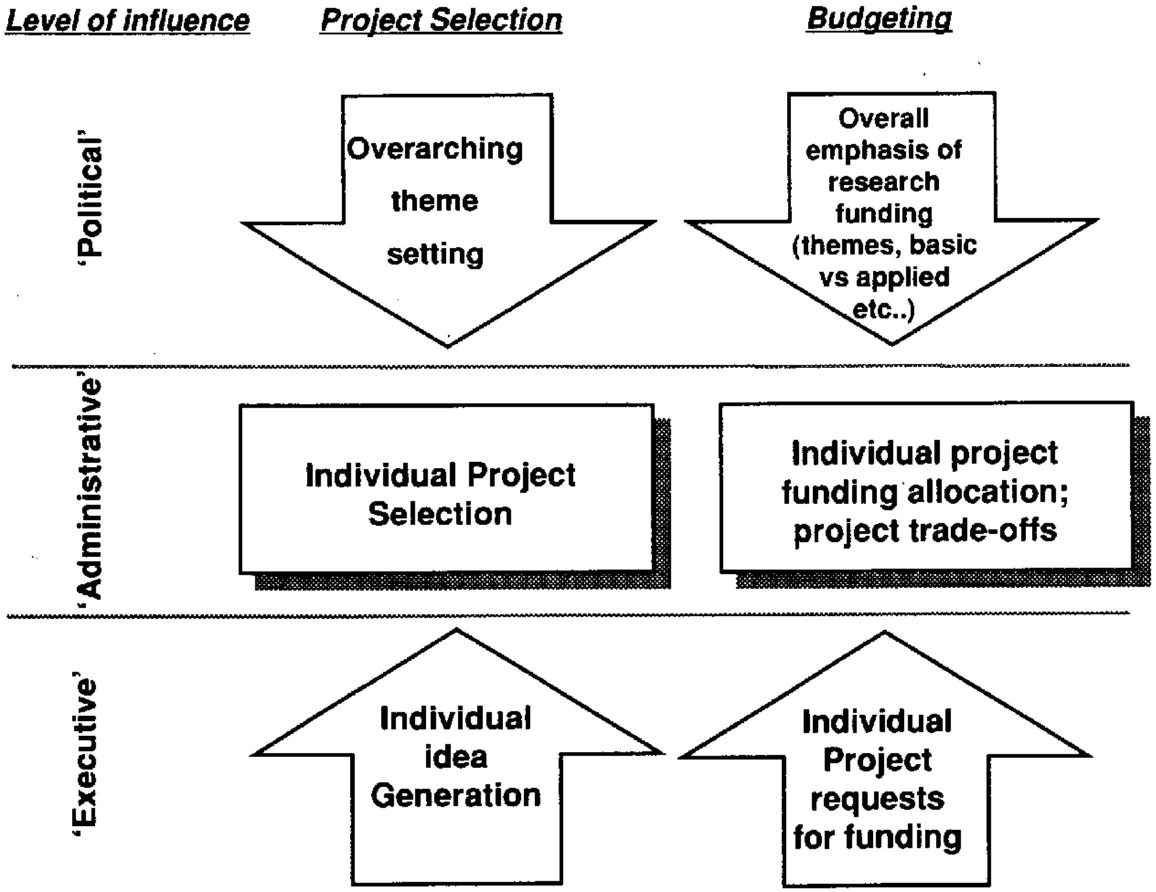
1.3 Outline of Funding System

The system of selecting and funding research in the US is a unique mix of top-down 'environment-creation' and 'theme-setting' and bottom-up 'idea-generation'.

米国での研究案件選択と出資の仕組みは、トップダウンの「環境創造」及び「テーマ設定」と、ボトムアップの「アイデア創出」との組み合わせにより成っていると特徴付けられる。

絵と説明が
合っていない…

Venture Capital の Selection と 類似と同じか…

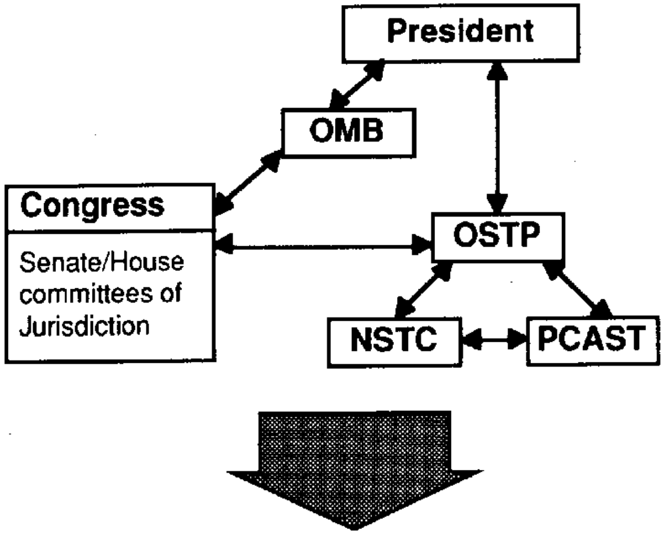


- Ⅰ Top-down coordination is a major strength of the system because if creates a structured envionment in which IT R&D is driven by (but not restricted to) a few high-level themes
- Ⅱ Overarching themes, and their coordinating bodies, play a key role in stimulating discussion between agencies and aligning their research interests towards common goals
- Ⅲ From the bottom up, ideas for projects are generated by ongoing interaction between research institutes and funding institutes
- Ⅳ Two distinct methods of program selection at the agency level provide a balance of immediate commercial-goal and long-term knowledge-generation approaches
- Ⅴ Budget-setting is an iterative, interactive process involving every level of the decision-making hierarchy

System - I - Top-down coordination

Top-down coordination is a major strength of the system because it creates a structured envionment in which IT R&D is driven by (but not restricted to) a few high-level themes.

トップダウンでの調整により、ITの研究開発全体として幾つかの大きなテーマ領域に重点を置くことが出来(必ずしも縛られないが)、それはこの仕組みの中で大きな強みと考えられる。



President

OMB

Congress

Senate/House committees of Jurisdiction

OSTP

NSTC

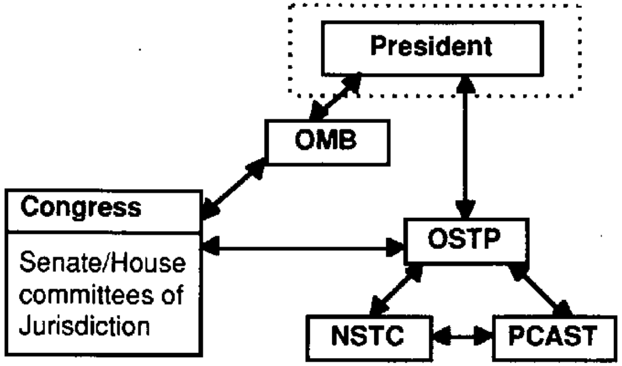
PCAST

- Overarching theme setting
- Empowerment of theme-based ‘virtual’ agencies such as the HPCC to pursue themes
- Setting of general directions of research funding basic versus applied, federal labs vs academic

- The role of high-level top-down coordination is shared by the President and Congress, together with various supporting executive offices.
- The greatest strength of the US approach is that high-level input is provided in setting research directions, but without dictatorial setting of specifically what money should go where
- While this exposes themes of research and budgets (which, by the very nature of research require some long-term stability) to the political tide, it also ensures that R&D directions reflect changing overall national priorities

The president takes primary nominal responsibility for all aspects of policy creation, direction setting, budget management and administration.

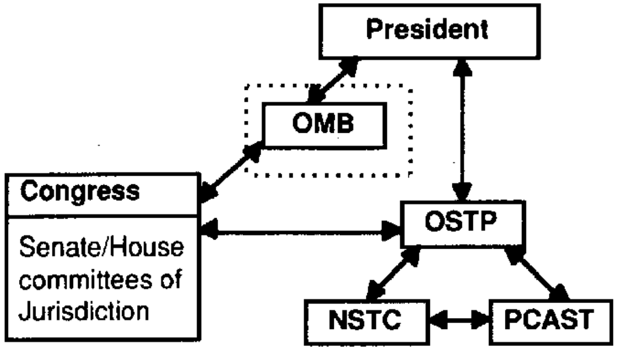
トップダウンの仕組みの頂点に立つのは、政策策定、方向性の設定、予算の管理等、全ての面において名目上の責任を持つ大統領である。

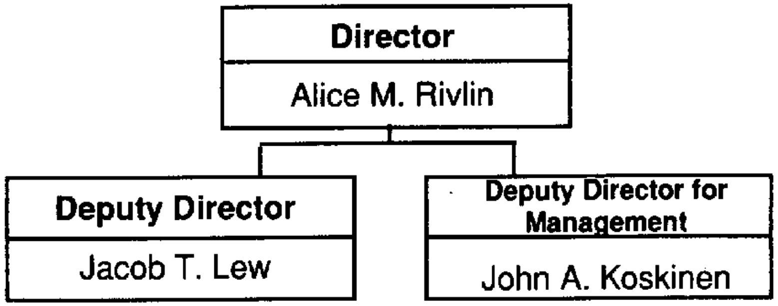


- takes nominal responsibility for budget submission to Congress
- signs final Congress-approved/amended budget into law
- creates coordinating / advisory bodies such as PCAST/NSTC by Presidential decree
- sets political agenda against which key research themes are created - the "NII" (National Information Infrastructure) initiative began as a 1992 Clinton administration campaign weapon

System - I - Top-down coordination - OMB

The key role of the OMB is in budget preparation, as part of its wider role of overseer of the federal budget.
OMB(White House Office of Management and Budget)は政府予算全体の監督を行う中で、特に予算の作成が重要な役割である。



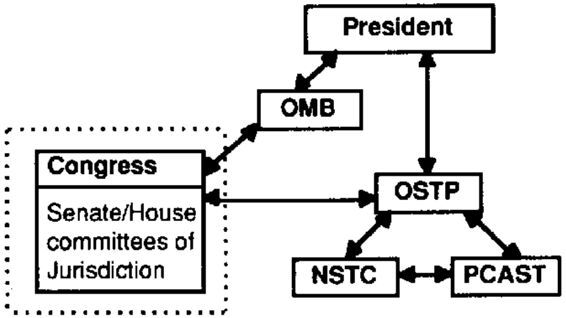


- The OMB (White House "Office of Management and Budget") takes (executive) responsibility for preparation of the budget
- supervises its administration in agencies
- evaluates the effectiveness of agency programs, policies and procedures (at a relatively high level)
- assesses competing funding demands between agencies (again only at a relatively high level)
- has been the prime mover behind the trend towards "metrics" (quantitative indicators of effectiveness) in US R&D management (a trend largely opposed by the research community)

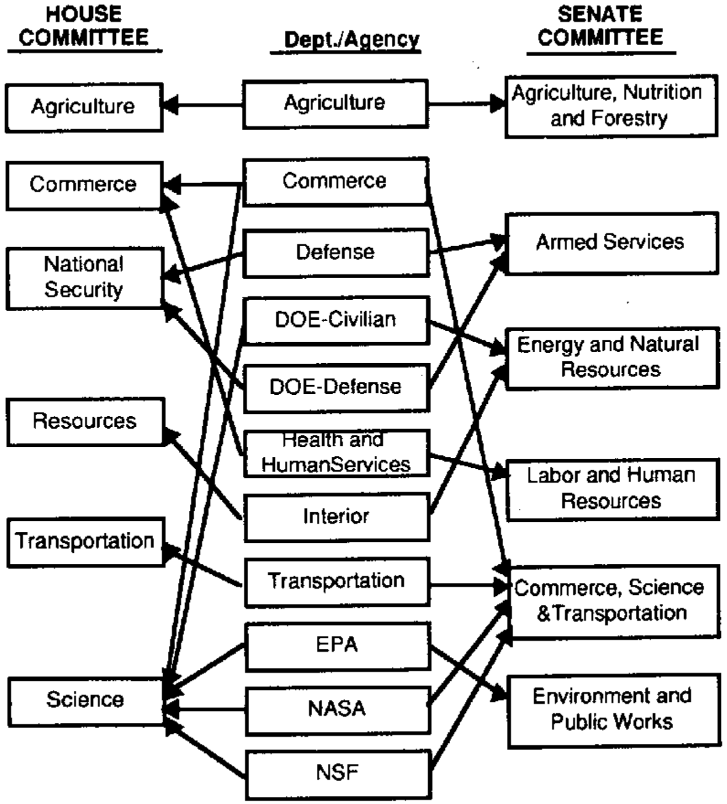
metricsを設定しようとすれば、必ずoppositionが発生する。
あたりまえのこと。

System - I - Top-down coordination - Congress

Congress has the final say on the R&D Budget after submission by the OMB.
議会はOMB作成の予算に対して、最終的に修正・承認権を持つ。



- There is no Congressional coordinating authority for R&D
- The House Committee on Science (HCS) comes close, but does not have any legislative authority
- Congress frequently amends or cuts proposed budgets, and may replace requested R&D funds with little regard for any interagency strategy
- The disaggregation of budgets into the jurisdictions of appropriations committees means that, for example, the NSF budget must compete for the same pot of money as the EPA (Environmental Protection Agency)
- The 104th Congress has however used some procedures which offer promise of better coordination in future years
  - HCS held hearing on federal R&D in Jan. '95
  - House Budget Committee has established several working groups



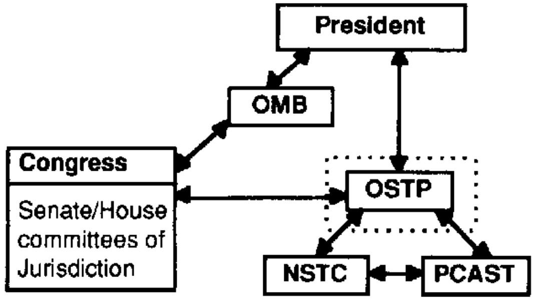
大

こんなものを組み立てているのは、資料の枚数を増やすだけの意味しかない。[本質は何…]

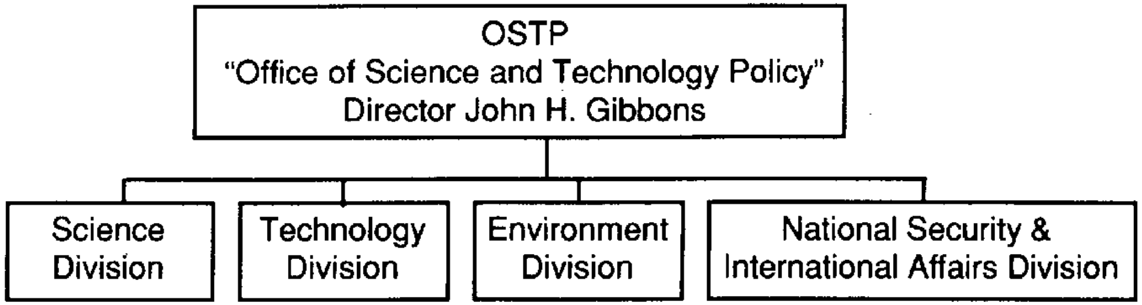
Congressにおいて、Dept. Agencyが権限を持っていることを強調したいのか…

The OSTP provides highest level coordination of policy formation, and acts as the science policy interface between the President, Congress and advisory bodies such as NSTC and PCAST.

OSTP(Office of Science and Technology Policy)は、政策策定の調整を最も高いレベルで行い、科学技術政策に関して大統領、議会、諮問機関の間を取り持つ。



/ここの持つ役目を下きそうだ…


OSTP
"Office of Science and Technology Policy"
Director John H. Gibbons

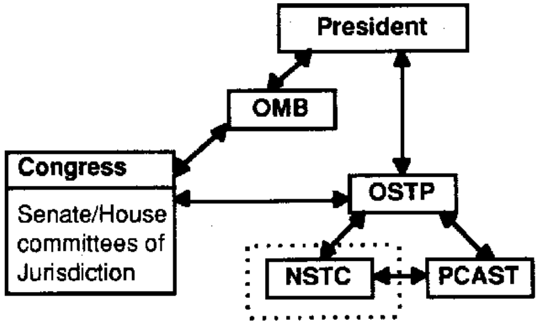
- Science Division
- Technology Division
- Environment Division
- National Security & International Affairs Division

- The OSTP's key roles include:
  - providing expert advice to the president
  - acting as interface to congress
  - forming & overseeing coordination/advisory bodies such as PCAST and NSTC

- The OSTP has no budgetary responsibility (that belongs to the OMB) and little policy responsibility (the limelight goes to PCAST and NSTC)

The NSTC (National Science and Technology Council) is the latest effort by US government to provide high level R&D coordination, but its effectiveness is not yet known.

NSTC(National Science and Technology Council)は、国の研究開発の調整を高いレベルで行うための機関として最近に作られたが、その効果はまだ判然としない。



どこかの国にもありそうな
機関に見えるが……

- The NSTC was established by executive order in November 1993 as a “virtual agency” for coordination of Federal R&D and science, space and technology policy , and for improving the effectiveness of government of science & technology
- In its two years of operation, the NSTC has put in place a coordinated “strategic planning” initiative designed to facilitate cross-agency communication as well as numerous smaller programs and forums
- It is too early to say, however, whether the NSTC will have any major impact on the system of government funding. Previous bodies have had limited effect, owing to resistance from OMB, congressional appropriation committees and changing political tides

high-level R&D coordination.
理念.

→ 言いたいことを言ってみるを受けとめる機関
があると…→ 意味結構

← → これでは、effectiveness is unknown] → いわせるだけに終る…

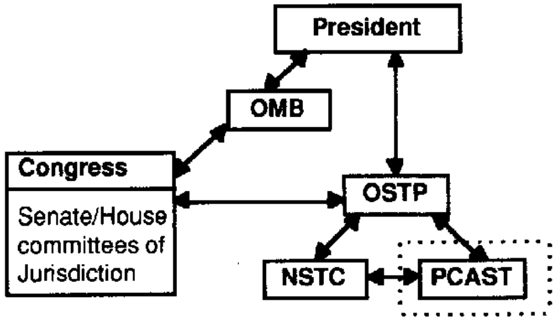
結局は Budget Allocation
political tides に
左右される…

ADLは、常識の範囲で
物を見ている気がする…

System - I - Top-down coordination - PCAST

PCAST (the Presidential Committee of Advisors on Science and Technology) serves as the highest-level academic and private-sector (industry and academia) advisory group to the President and NSTC.

PCAST(The Presidential Committee of Advisors on Science and Technology)は、大統領とNSTCに対しての諮問機関であり、学界・産業界のトップレベルのメンバーから成る。



HPにこんな人もいたな・・・

Co-chairs

John H. Gibbons	John Young
Head of OSTP	Former CEO of HP

ACADEMIA

Francisco J. Ayala	Professor of Biological Sciences and Professor of Philosophy, UC Irvine/President of AAAS
Murray Gell Mann	Professor Santa Fe Institute
John P Holdren	Professor of Energy, UC Berkeley
Mario J. Molina	Professor of Environmental Sciences, MIT
Peter H. Raven	Professor of Botany, University of Washington
Sally K. Ride	Director, California Space Institute, University of California/ Professor of Physics, UCSD
Judith Rodin	President, University of Pennsylvania
Charles M West	President of MIT, Professor of Mechanical Engineering

INDUSTRY

Norman R. Augustine	CEO, Martin Marietta
David Hamburg	President, Carnegie Corporation
Diana MacArthur	CEO and co-founder, Dynamac Corporation
Charles A. Sanders	Chairman and CEO, Glaxo Inc.
David E. Shaw	CEO, D.E. Shaw & Co.
Virginia V. Weldon	Senior VP for Public Policy, Monsanto
Lilian Shiao-Yen Wu	Researcher, IBM's Thomas J. Watson Research Center; Director Intl. Institute of Forecasters

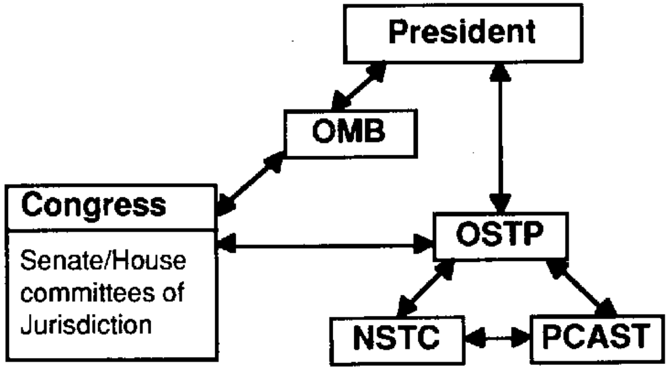
POLICY

Shirley M. Malcolm	Head of Directorate for Education and Human Resources Programs, AAAS

* See Appendix for detailed biographies

Overarching themes and their coordinating bodies created in the top-down process play a key role in stimulating discussion between agencies and aligning their research interests towards common goals.

これらトップダウンの仕組みを構成する大きなテーマ領域とその調整機関により、省庁間の議論が促進され、各省庁での研究開発が共通の目的に向かって方向性が揃えられる。


President
OMB
Congress
Senate/House committees of Jurisdiction
OSTP
NSTC
PCAST

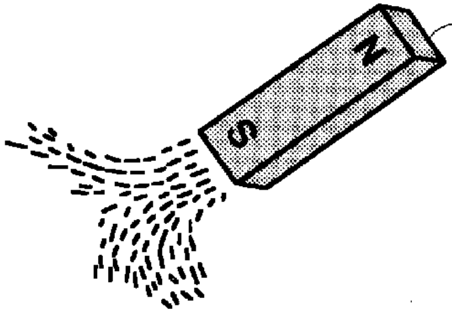
Empowering/coordination bodies

HPCC

- Detailed research directions
- "Alignment" of agency /department research interests

- Bodies such as the HPCC act as "magnets" aligning the objectives of other bodies (the agencies and departments that actually allocate funding budgets), but without directly controlling budgets themselves

これが大事なことがら
ではないのか?



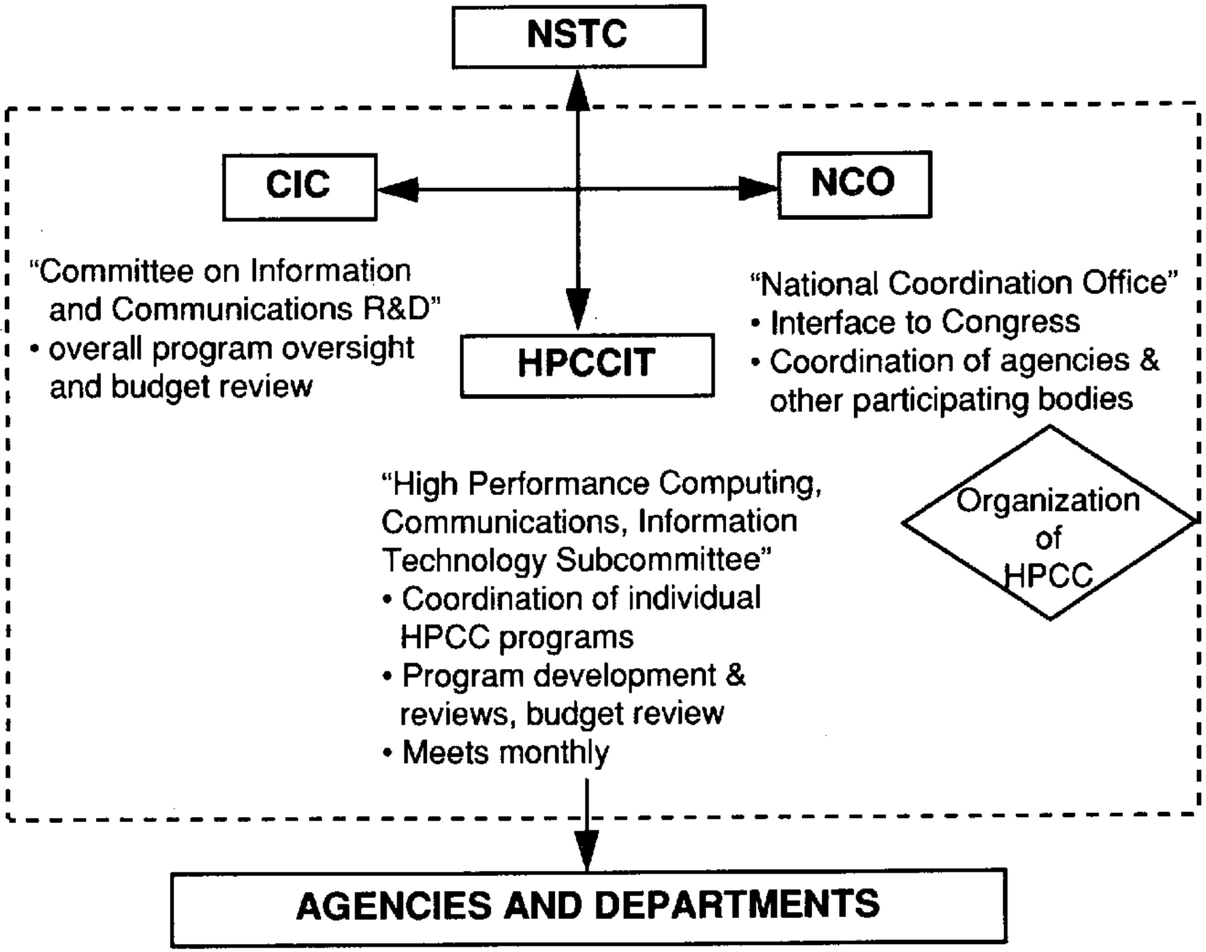
- The HPCC acts as a kind of "virtual agency" setting broad frameworks within which the agencies can adhere to their individual missions
- In addition the HPCC plays a key role in stimulating discussion and communication outside "traditional" hierarchical channels - not just inter-agency,but also vertically.

stimulate
discussion
and communication.

ここらあたりの仕組をどう表現して行こうか…

The HPCC is an ‘inter-agency’ ‘inter-functional’ initiative which coordinates much of the IT activity of many of the larger agencies and departments.

HPCCは省庁間・機能間を横断するプログラムであり、それら省庁のIT研究開発の多くの部分を調整する役割を果たす。



NSTC

CIC

“Committee on Information and Communications R&D”
- overall program oversight and budget review

NCO

“National Coordination Office”
- Interface to Congress
- Coordination of agencies & other participating bodies

HPCCIT

“High Performance Computing, Communications, Information Technology Subcommittee”
- Coordination of individual HPCC programs
- Program development & reviews, budget review
- Meets monthly

Organization of HPCC

AGENCIES AND DEPARTMENTS

The key aim of the HPCC is aligning the IT research interests of the agencies and departments around common targets, which it has broken into five components.

HPCCの重要な目的は、各省庁でのIT研究開発領域を共通の目的に向かって足並み揃えることである。その共通の目的は5つの大重点領域プログラムとして設定されている。HPCCは大きな目的を定義しているが、その目的の達成のための手段となる個々の技術については指定せず、むしろ違った技術間の競争を許容している。

度

こんなことまで、タイトルには書いてないが、、、

HPCC Components

HPCS ***"High Performance Computing Systems"***
- Accelerated development of scaleable computing systems and supporting technologies

NREN ***"National Research and Education Network"***
- Development of advanced network technologies and their deployment within the research community

ASTA ***"Advanced Software Technology and Algorithms"***
- Prototype solutions to "Grand Challenges", improvement of algorithms and software tools

Abbreviation 1.x...

IITA ***"Information Infrastructure and Technology Applications"***
- Prototype solutions to "National Challenges" and accelerated deployment of NII enabling technologies

BRHR ***"Basic Research and Human Resources"***
- Support for research, training and education in computer science

Grand Challenges
(These overlap strongly with ASTA.) applied fluid dynamics, environmental modeling, ecosystems simulation, biomedical imaging and biomechanics, molecular biology, molecular design, cognition, fundamental computational sciences,......

National Challenges
(These overlap strongly with IITA.) digital libraries, public access to government information, electronic commerce, civil infrastructure, education and lifelong learning, energy management, environment monitoring, health care, manufacturing,......

本当は
国策というか、し
いることになるすごい。

Grand Challengeと
National Challenges

The HPCC has defined abstract "goals", rather than the technologies needed to achieve them. Within each program different technologies and approaches may compete.

HPCCとG/N 各々が見えてきた。
その、関係と[illegible]が見えた

Although added last* the IITA component new receives approximately one third of the HPCC total budget appropriation:

IITA(Information Infrastructure and Technology Applications)は最も後に加わったプログラムだが、現在では予算割当の3分の1近くを受けている。

HPCC Components

Cross-Allocation of HPCC Funding by Agency/ Department and by Component

All figures are percentages of 1996 budget of $1165 million

↑ $1.1B (Government の内訳)

Agencies/Departments

	HPCS	NREN	ASTA	IITA	BRHR
ARPA	8.2%	6.0%	2.9%	13.5%	0.5%
NSF	2.0%	4.7%	11.4%	3.7%	5.2%
DOE	0.7%	1.5%	6.4%	0.3%	1.8%
NASA	0.7%	1.8%	6.6%	2.3%	0.3%
NIH	0.4%	0.2%	2.4%	2.8%	1.0%
NSA	1.4%	0.9%	1.1%		
NIST		0.2%	0.3%	2.4%	
NOAA		0.6%	0.6%		
EPA			0.8%		
ED			1.0%	0.2%	0.3%
AHPCRC				0.7%	
VA				2.0%	
% of total	13.4%	15.9%	33.5%	27.9%	9.1%

* HPCS, NREN, ASTA, and BRHR were established in 1992 with the 1991 Act that created the HPCC. IITA was set up in the second year of operation, 1993.

3-4年目のproject

System - II - Role of overarching themes - HPCC

The Act which created the HPCC comes up for review this year, and it is currently unclear whether the program will be continued.

HPCCを生み出した法律は今年見直しの期限が来る。HPCCを継続するかどうかはまだ不明である。

→これは情勢であり → 実績なのか 必要かどうかの見識が大事であろう。

AITECはMissionの予算を足しもする…

- The aim of the HPCC was not so much to get agencies to fund computing research (they already did) as to establish broad objectives and direct agencies to coordinate their own programs accordingly, through encouraging frequent inter-agency and vertical communication
- This aim has now largely been fulfilled, and although such communication is not formalized, it is certainly institutionalized to a large extent. It is therefore unclear whether there is a continuing need for the HPCC
- The initiative now encompasses much of the nation's IT research, which would certainly continue should the program cease (reclassified again, much as it was reclassified into the program in the first place)
- However, many people (including John Toole, current head of HPCC) feel that the focus of HPCC is too important to decentralize
- Additionally there is Presidential reluctance to open up a Congressional debate over government funding of computing research in general, especially with an election fast approaching

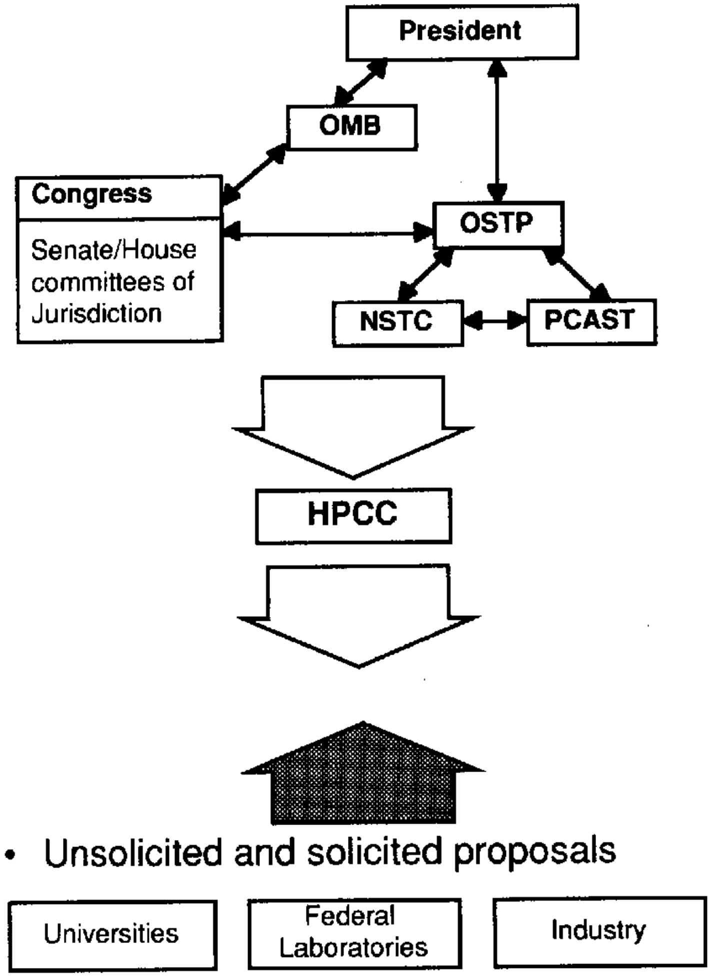
92 96

いずれにしても これは継続 ~~[illegible]~~ 。

System - III - Bottom-up idea generation

From the bottom-up, ideas are generated by ongoing interaction between research institutes and funding institutes, crucial for stimulating competition.

研究のアイデアはボトムアップで研究機関から出資省庁に上がって来る。健全な競争のためにもこのボトムアップの流れは重要である。



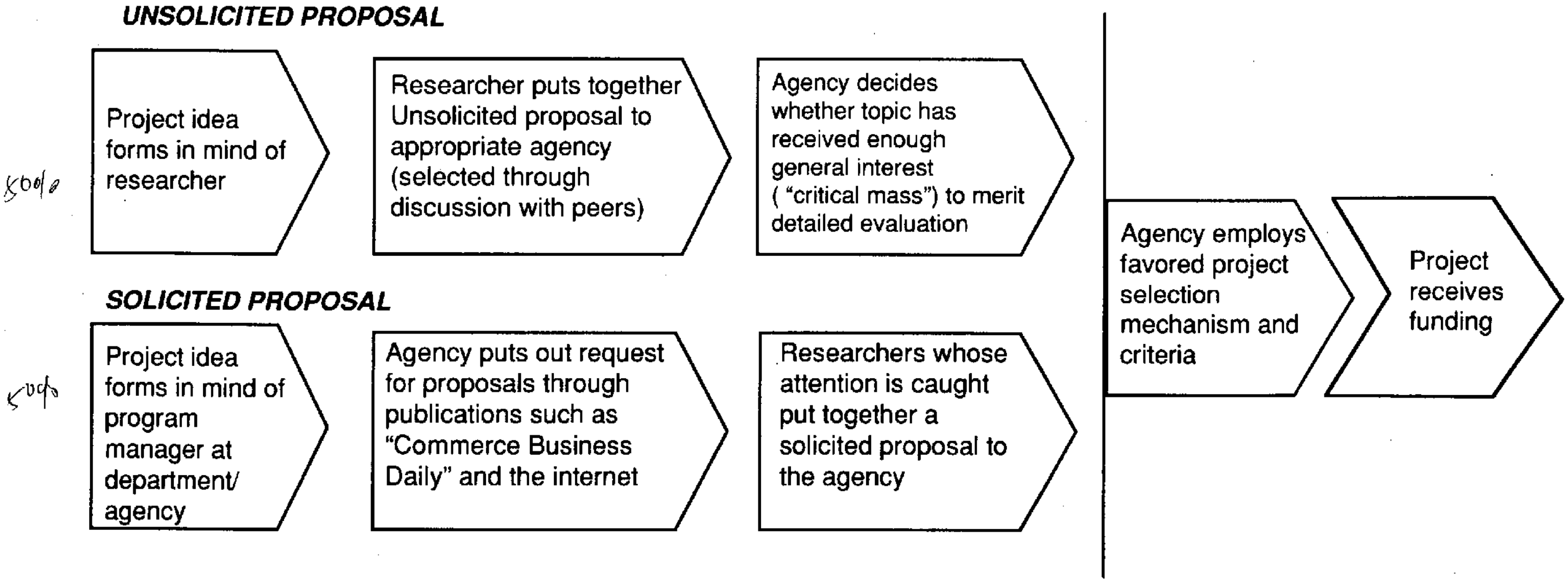
- Unsolicited and solicited proposals

- Ideas are generated at the grass roots level by research institutions, either in response to prompting from funding institutions or as a result of internal chains of events
- They are then formalized in "solicited" or "unsolicited" proposals to the funding bodies
- The benefits of allowing research ideas to permeate up from the bottom are crucial:
  - researchers work on their own ideas - a much more motivating and rewarding experience
  - researchers compete directly for funds (and program directors can readily compare competing programs, given the overall top-down coordination)
  - there is always scope for maverick revolutionary ideas to permeate through

System - III - Bottom-up Idea Generation - Solicited and Unsolicited Proposals

Project ideas are formalized by research institutions as ‘solicited’ or ‘unsolicited’ proposals to the funding bodies.

プロジェクトのアイデアは、研究者から出資省庁への提案により具現化される。提案には特定テーマでの募集に応じるものと、募集に関わりなく自由に提案するものがある。



UNSOLICITED PROPOSAL

50%

- Project idea forms in mind of researcher
- Researcher puts together Unsolicited proposal to appropriate agency (selected through discussion with peers)
- Agency decides whether topic has received enough general interest (“critical mass”) to merit detailed evaluation

SOLICITED PROPOSAL

50%

- Project idea forms in mind of program manager at department/ agency
- Agency puts out request for proposals through publications such as “Commerce Business Daily” and the internet
- Researchers whose attention is caught put together a solicited proposal to the agency

- Agency employs favored project selection mechanism and criteria
- Project receives funding

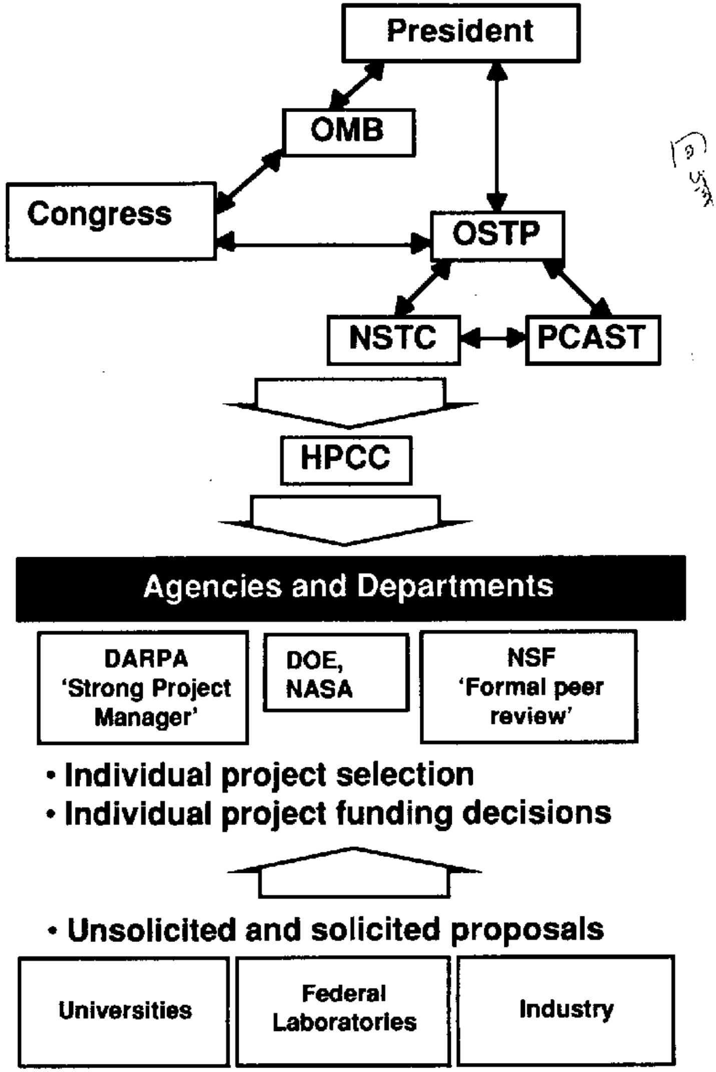
と言っている

- **Estimates vary, but about half of projects which eventually receive funding come from solicited proposals and about half come from unsolicited proposals**
- **The split varies by agency: DARPA, which tends to focus research around more specific end-results, works almost exclusively on solicited proposals, whereas at the NSF unsolicited proposals are more common**

Agencyにより
特性

Two distinct methods of program selection at the agency level provide a balance of immediate commercial-goal and long-term knowledge-generation approaches.

省庁におけるプロジェクト選定には2つの方式があり、それによって短期的な商業化目的と長期的な知識の創出目的のバランスが取られている。



President

OMB

Congress

OSTP

NSTC

PCAST

HPCC

Agencies and Departments

DARPA 'Strong Project Manager'

DOE, NASA

NSF 'Formal peer review'

- **Individual project selection**
- **Individual project funding decisions**

- **Unsolicited and solicited proposals**

Universities

Federal Laboratories

Industry

同じ事をいってる

- Decisions on which projects to fund and how much money to allocate are made by individual departments and agencies
- It is within the departments and agencies that the top-down and bottom-up influences are brought together
- Two distinct models for program-selection are in operation
  - Formal peer review (practiced by the NSF) 同僚、仲間
  - Strong project manager (exemplified by DARPA) 例えば
- Although each system has advantages and disadvantages, the two approaches complement each other well:
  - The NSF approach sustains long-term research in fields where commercial goals are not yet visible
  - In contrast DARPA is geared towards research which leads more directly to a practical result
- The two approaches tend to lend themselves to research with different time-horizons - peer review to longer-term, since decisions rely more on 'academic interest' in topics;strong program manager to shorter-term,since decisions rely more on harder-headed more commercially-oriented decisions.

The peer review system employed at the NSF is key to sustaining long-term research, but prone to abuse in times of fierce competition for budgets.

ピア・レビュー(同領域専門家グループによる評価)はNSFで採用されているプロジェクトの選定方式で、長期視野の研究を継続していくのに適している。しかし、予算への競争が激しい時節においては、濫用の懸念がある。

警告を与えているものもある。

Peer/Merit Review

- Agency puts together peer review panel from working scientists and engineers from diverse backgrounds with deep knowledge of area
- Reviewers provide disinterested judgments on

  利害関係のない。

  - soundness of research plan
  - scientific significance of proposed work
  - competence of researchers
  - likelihood of success
- Reviewers remain anonymous
- Since 80s the term "merit-review" has been used to indicate that program managers must take into account general policies of the Agency in addition to the views of peers
- Some agencies, such as NIH (National Institutes of Health), make limited use of second level of reviews. (internally or by higher-level coordinating bodies) to take into account national priorities. The HPCC occasionally (not regularly) plays this role.

- Peer review has been a cornerstone of US research project selection policy for over 20 years, and according to government statistics today accounts for 30% of federal R&D. In IT, the proportion is likely to be a lot higher, since the integration of the research community with government and industry is higher than in many other areas of research.

  根本原理である。

- Peer review is ideally suited to an era when progress is limited only by supply of good ideas - with rejection rates of 20 - 60% the risk of selection of less valuable projects would inevitably be high if judgment were restricted to the narrow experience of program managers
- However, the system relies on honesty and ethical behavior - a reviewer's pledge that he will not abuse the possibility open to him of delaying response to or denigrating the work of rivals.
- According to many senior academics* in today's era of fierce competition for increasingly scarce resources, what was previously a purely intellectual competition is gradually turning into a system actively encouraging unethical behavior.

最近は競争が激しくて
倫理的にいかがわしいことも
生じてきている。

---

* Such as David Goodstein, Professor of Physics, Caltech

The 'strong program manager' approach employed at DARPA is more suited to research with a more immediate tangible application, since it relies heavily on the competence of individuals.

それに対してプログラムマネジャー方式は、DARPAに代表されるような短期視野の研究分野に向いている。プロジェクトの選定は、大きな権限を持つプログラムマネジャー個人の資質・判断によるところが大きい。

Strong Program Manager

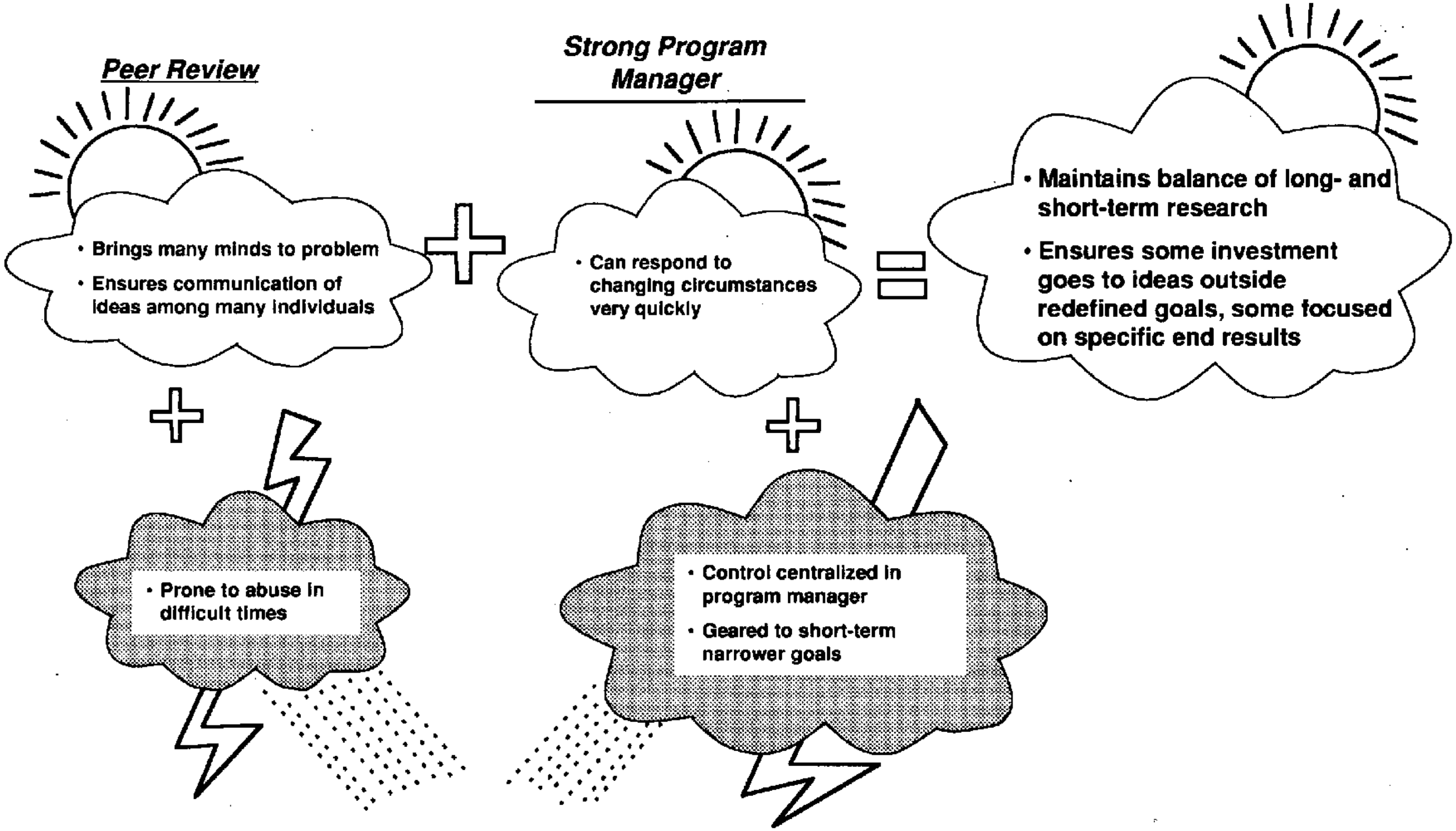
- Program Managers have responsibility for being well-informed about the state of the art of their specialties, and for selecting appropriate researchers to investigate areas they deem of greatest importance to the agency's mission
- Program Managers devote a considerable proportion of energy to soliciting views of peers, but are not bound by a formal process
- In addition to the general policies of the agencies, the views of peers and practitioners, the program manager can therefore exercise his own judgment somewhat in the manner of a venture capitalist

むしろ逆ではないか
[illegible]が見えるの
ではないか？

- The actual people involved in a proposal decision in the 'strong program manager' approach are quite similar to the peer review approach
- The crucial difference is that the program manager is not bound by a "process" which makes the decision for him
- To ensure the accountability of program managers, therefore, programs with shorter term goals for which the success or failure can more objectively be seen are crucial.

Although each system has advantages and disadvantages, overall, research benefits from having both systems in play.

どちらの方式にも長所短所があるが、国全体の研究開発として見れば、両方式の共存することが利益をもたらしていると言える。



Peer Review

- Brings many minds to problem
- Ensures communication of ideas among many individuals

+

- Prone to abuse in difficult times

+

Strong Program Manager

- Can respond to changing circumstances very quickly

+

- Control centralized in program manager
- Geared to short-term narrower goals

=

- Maintains balance of long- and short-term research
- Ensures some investment goes to ideas outside redefined goals, some focused on specific end results

Other mechanisms are in use by agencies less involved in IT research, but peer review and strong program manager are the principal mechanisms among the 'big 4'.

その他の方式もIT関連の少ない省庁では使われているが、IT研究開発の主要4省庁ではピア・レビューかプログラムマネジャー方式が採用されている。

Competitive Procurement

- Standard procedure for procurement followed with selection performed by comparison of project against predefined selection criteria
- Low-level technical employees or consultants used to perform evaluation
- Often used for projects of direct interest to government

Formula Funding

- Used to allocate funds among institutions, who then internally allocate to specific programs
- Very rarely used for IT-related research

	Agencies' preferred mechanism
DARPA	Strong Program Manager
NSF	Peer/Merit Review
DOE	Primarily Strong Program Manager (although slightly handicapped by the requirement to keep internal laboratories busy)
NASA	Primarily Strong Program Manager (but same issue as for DOE)

The central role played by program managers in the two key systems of program selection means that choosing the right type of individual is of paramount importance.
プログラムマネジャーの果たす役割の重要さを考えると、本当に有能・最適な人材を選ぶことは非常に重要である。

Typical Program Manager Background

- Technical qualification (Ph.D. from leading institution) or other demonstration of significant technical depth.
- Five or more years experience after qualification , often a combination of academia and industry or the military.
- Around 35 years old, with an ability to combine the maturity of age and experience with the freshness, innovation and dynamism of youth.
- A high level of managerial skill, including:
    - -leadership
    - -people management
    - -project management
    - -public speaking
    - -financial management
    - -decision-making
- Enthusiasm and motivation to succeed

- The degree of responsibility given to program managers/directors means that the right combination of skills is vital
- Program managers have to combine an interest in technical detail (to the extent of getting their hands dirty) with a maturity and high level vision
- In particular at DARPA, where the pace of life is fast and exciting compared with many of the more bureaucratic institutions, program managers are among the more highly-paid civil servants.

人気のテーマとは何?

隠岐. 時がたってしまった…

Additionally, the organizational structures of DARPA and NSF reflect the need to manage the two systems quite differently.

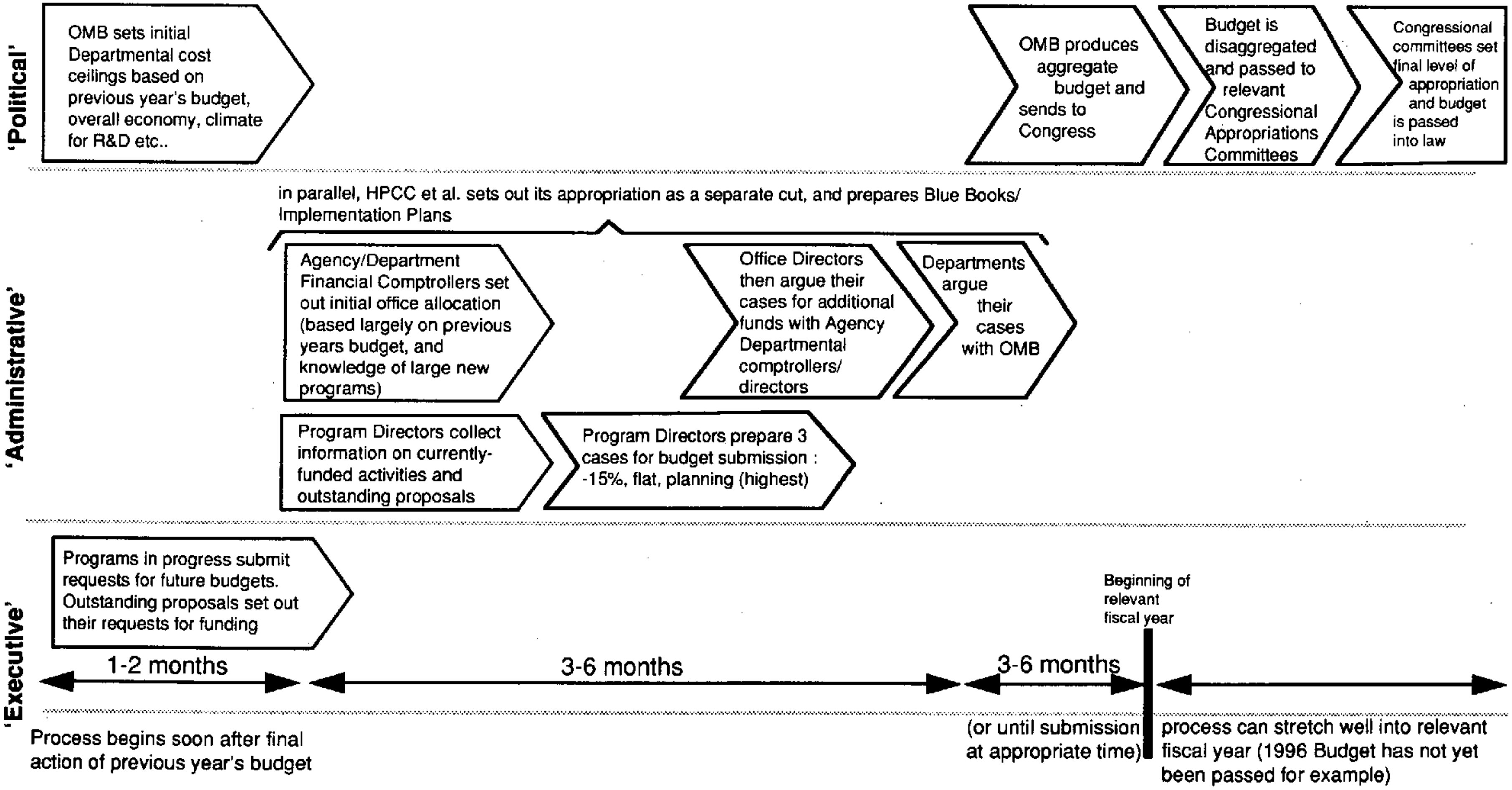
これら選択方式以外にも、DARPAとNSFの研究開発の運営形態には、対照的な相違が見られる。

Contracting characteristics of the NSF and DARPA

NSF	DARPA
Seven levels of hierarchy	Three levels of hierarchy (Program Manager, Office Director, DARPA director)
Much longer term investment in infrastructure development and "pencil-and-paper" research	20% annual project retirement rate やめる人？
Program manager budgets of $500,000 - $2 million 少ない、	Program manager budget up to $20 million /per
Huge fixed infrastructure and organization	Fewer than 200 program managers [illegible]
Approximately half unsolicited proposals	Only few unsolicited proposals

Finally, the actual annual budget-setting process itself is an iterative, interactive process involving every level of the decision-making hierarchy.

実際の年間の予算作成は、各レベルでの意思決定・折衝を繰り返し行うようなプロセスを経て行われる。



'Political'

OMB sets initial Departmental cost ceilings based on previous year's budget, overall economy, climate for R&D etc..

OMB produces aggregate budget and sends to Congress

Budget is disaggregated and passed to relevant Congressional Appropriations Committees

Congressional committees set final level of appropriation and budget is passed into law

'Administrative'

in parallel, HPCC et al. sets out its appropriation as a separate cut, and prepares Blue Books/ Implementation Plans

Agency/Department Financial Comptrollers set out initial office allocation (based largely on previous years budget, and knowledge of large new programs)

Office Directors then argue their cases for additional funds with Agency Departmental comptrollers/ directors

Departments argue their cases with OMB

Program Directors collect information on currently-funded activities and outstanding proposals

Program Directors prepare 3 cases for budget submission : -15%, flat, planning (highest)

'Executive'

Programs in progress submit requests for future budgets. Outstanding proposals set out their requests for funding

Beginning of relevant fiscal year

1-2 months

3-6 months

3-6 months

Process begins soon after final action of previous year's budget

(or until submission at appropriate time)

process can stretch well into relevant fiscal year (1996 Budget has not yet been passed for example)

1章のまとめ

この章のまとめとして、米国の研究開発に関する政策運営から学べる点を以下に挙げる。

- 米国政府IT研究開発出資は$27億、科学技術予算の7%にも上り、その額、ITに対する重要配分からして、相当な政策的重要性が見て取れる。
- トップダウンの研究開発政策は重点テーマ領域として示される。それは省庁横断的調整機関により各省庁に徹底され、国としての方向性が実施される。
- 政策的方向性・プログラムを大括りの目標として設定することで、個々の技術間に競争原理を働かせ、淘汰、切磋琢磨させている。
- ボトムアップの研究プロジェクト提案により、研究者間に競争原理を働かせ切磋琢磨させ、同時に革新的アイデアに門を開いている。

日本の場合は硬直的であり
競争原理が働かない。

- 短期・特定領域指向のプログラムと、長期・広領域指向のプログラムが両在することにより、国としての研究開発のバランスが保たれている。

国としての
バランス

- プロジェクト選定にはピア・レビュー式とプログラム・マネジャー方式がある。個人の資質に大きく頼る後者では、大変能力のある専門家を専任で登用する。

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*1　1996年3月までDARPAはARPAと呼ばれていた

2 Methods of Transfer of Technology to Industry

2.1 Underlying Philosophy

2.2 System and Mechanisms

2 Methods of Transfer of Technology to Industry

2.1 Underlying Philosophy

2.2 System and Mechanisms

Technology Transfer Philosophy

The US approach to transfer of the fruits of research to industry is based on three fundamental principles.
米国における研究開発成果の産業への移転は、3つの基本方針によっている。

The underlying mechanism is the Free market/ Competition

- brings out peoples' best and brings out the best people through natural incentivization
- entirely the opposite approach to striving for goals through regulation
- provides equal opportunities for all

The eventual aim is to provide public benefit

- increased quality of life
- increased employment
- regional development
- strengthening US international competitiveness

Industry is recognized as a vital link between research and public benefit

- clear distinction between the role of industry (commercialization) and the role of universities/labs (R&D up to but not including commercialization) →これはいいと思う。
  だから Technology Transfer がいる.
- building industries through new start-ups or adding to them through technology licensing
- widely perceived as being in the public interest to involve industry (rather than as providing tax payer dollars to industry for free) 不明

2 Methods of Transfer of Technology to Industry

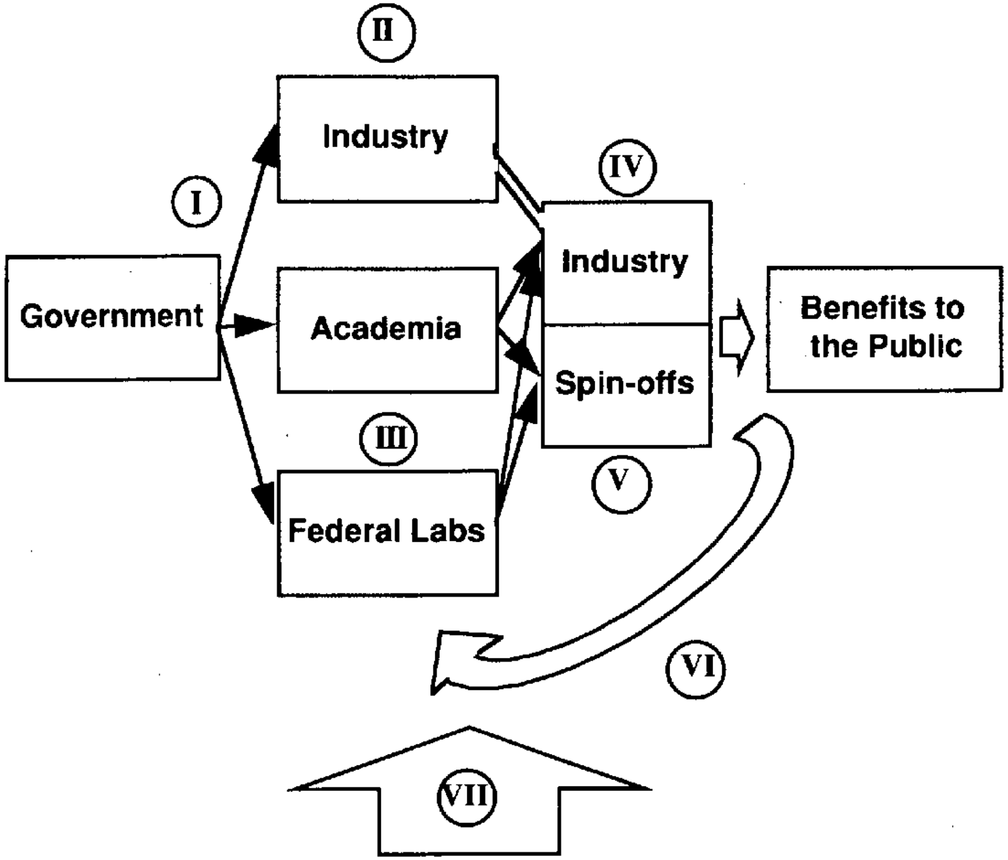
2.1 Underlying Philosophy

2.2 System and Mechanisms

Technology Transfer System - Overview

US Technology Transfer creates eventual benefit for the public through a combination of direct and indirect funding, and industry/academic collaboration and spin-offs.

米国の技術移転の仕組みは、産業への出資と大学・研究所への出資、産学連携とスピンオフ等の組み合わせにより、最終的に国民への利益を生み出している。



(II)
Industry
(I)
Government
Academia
(III)
Federal Labs
(IV)
Industry
Spin-offs
(V)
Benefits to the Public
(VI)
(VII)

(I) 政府による研究開発プロジェクトの委託

(II) 産業界における委託研究

(III) 大学・研究所における委託研究

(IV) 大学・研究所での研究開発成果の実用化

(V) スピンオフによる技術移転

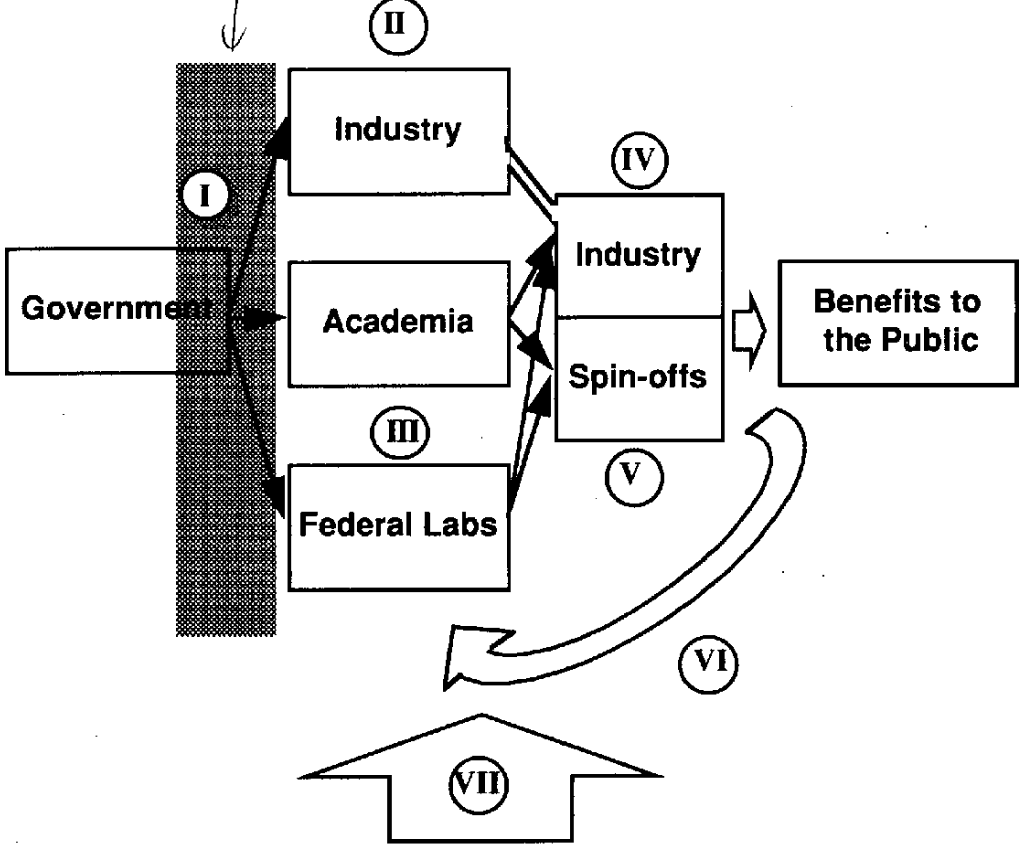
(VI) 社会ニーズのフィードバック

(VII) 基盤となる法体系

Technology Transfer System - I - Level Playing Field

Academia, federal labs and industry compete on a level basis for government R&D funds, enabling good ideas from any source to receive backing.
大学、国立研究所、及び産業は、政府資金に対して平等な立場で競争し、どの研究機関からであっても最も良いアイデアが出資を受けるようになっている。

日本の場合、ここに competition がないのではないか？…



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- The basic process for channelling research funds is competition between academia, the federal labs and industry
- This approach offers several advantages
  - it supplies a greater pool of ideas and approaches to any given problem from which to select the best ones
  - by involving industry it increases the likelihood of commercially - acceptable approaches being selected at the outset
  - by increasing the quantity of alternative recipients of funding, it increases the motivation of parties to ensure good results for the research they do win funding for
- Free competition is to some extent constrained by the missions of the individual funding agencies
  - NSF's focus on knowledge-generation lends weight to academic contenders for money
  - DARPA needs to ensure a viable defense industry, as well as merely funding defense research

There are therefore two approaches to transfer of technology into the private sector - direct funding of industry and leverage of academic/government research.
産業へ技術移転をしていくのに、産業への直接出資と、大学・研究所での研究を産業に移転していく2つの道がある。

Direct Funding of Industry IT R&D

- 45% of total government-fundedIT R&D ($1.2 billion)
- 3 key mechanisms : procurement, grants, cooperative agreements
- several specific 'virtual-agency' type programs, as well as agency self-coordinated funding

Leveraging Academic / government IT research into Industry

- 55% of total government-funded IT R&D ($1.5 billion)
- Two key mechanisms: academic/industry cooperation (which itself takes several forms) and spin-offs
- Characteristized by much on-going discussion, feedback, and mobility of people/resources

Technology Transfer System - I - Level Playing Field

As a result, a significant amount of government research funds goes directly to industry, as well as to universities and laboratories.

政府の研究開発資金は、その相当が産業に出資され、大学・研究所と匹敵する重要さになっている。

Industry	firms in the private, commercial sector, regardless of size (from small businesses to large corporations), inside the U.S.	~ 45%
Government Agencies and R&D Labs	U.S. government agencies themselves (e.g. NASA conducts much of its research itself) and federally funded R&D centers administrated by universities, industry, or non - profit organizations	~ 34%
Universities and colleges	universities and colleges of any size and reputation inside the U.S.	~ 17%
Others	non - profit organizations, international agencies, ...	~ 4%

(FY95 data, but distribution is stable over time)

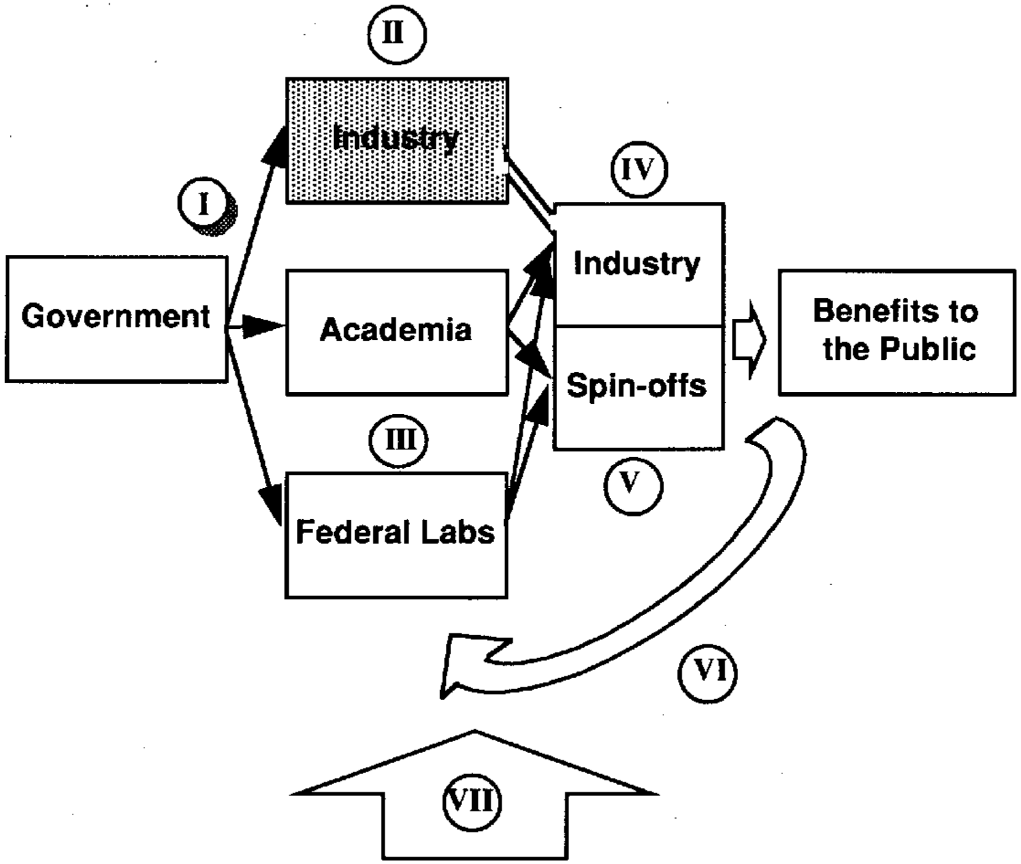
かなり出ているような
感じがする...

日本との比較
ができるのではないか??

Technology Transfer System - II - Direct Industry Funding

Money is distributed directly to industry through a number of agencies and virtual agencies using several mechanisms.

産業への出資は、色々な省庁とプログラムを通じて行われている。



Technology Transfer System - II - Direct Industry Funding

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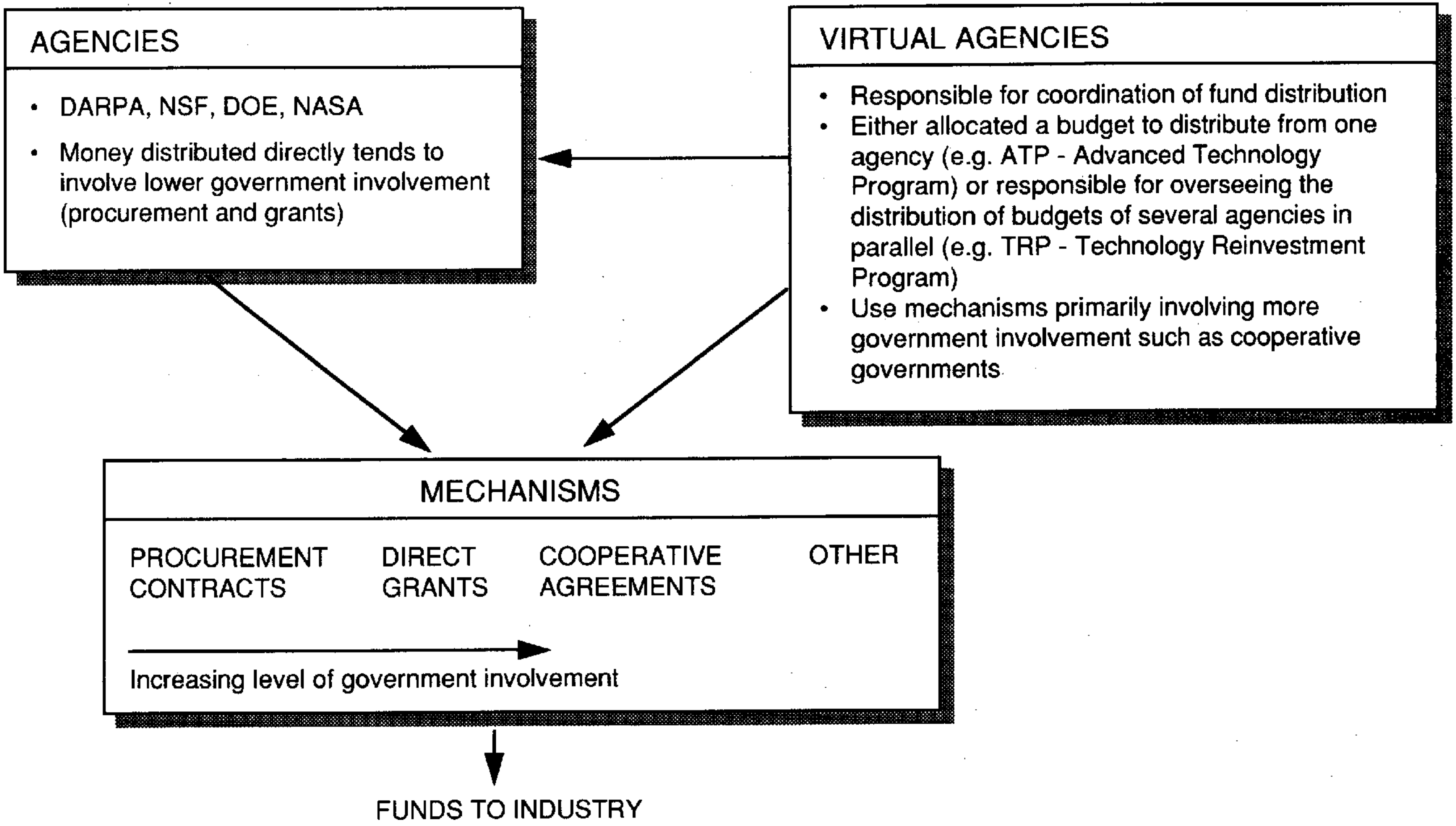


AGENCIES

- DARPA, NSF, DOE, NASA
- Money distributed directly tends to involve lower government involvement (procurement and grants)

VIRTUAL AGENCIES

- Responsible for coordination of fund distribution
- Either allocated a budget to distribute from one agency (e.g. ATP - Advanced Technology Program) or responsible for overseeing the distribution of budgets of several agencies in parallel (e.g. TRP - Technology Reinvestment Program)
- Use mechanisms primarily involving more government involvement such as cooperative governments

MECHANISMS

PROCUREMENT CONTRACTS | DIRECT GRANTS | COOPERATIVE AGREEMENTS | OTHER

Increasing level of government involvement

FUNDS TO INDUSTRY

Technology Transfer System - II - Direct Industry Funding

A wide variety of mechanisms is used to fund private sector R&D.
産業への出資には様々な形態が使われる。

Procurement Contracts

- Used when primary purpose is to acquire supplies or services
- Generally do not involve advancement of the state of the art, improvement of the technology base etc.
- In R&D, usually 'cost-reimbursement' contracts rather than 'fixed-price'

補助金、助成金

Grants

（認可.）

- Used when primary purpose is to stimulate R&D
- More an 'investment' than a purchase
- Degree of government involvement is not substantial
- Procurement contract regulations do not apply, allowing some flexibility over for example IP rights

Cooperative Agreements*

- Basically same as grant, but used when substantial government involvement needed to:
  - transfer government knowledge
  - monitor progress and milestones

↑

Grantsに似ているが
監視機構が備わるらしい

Other Transactions

- Loan agreements
- Coordinated research
- Consortia
- Joint-funding arrangements
- Reimbursable agreements

Increasing government involvement →

* Not so-called 'CRADAs' (Cooperative Research and Development Agreements) which cannot legally involve any transfer of funds to industry

CRADAは Industryがダメ...

Technology Transfer System - II - Direct Industry Funding

No overall coordination takes place of funds distributed to industry, however, and each organization with funds to distribute has a different goal.

産業への出資について全体的な調整はないが、出資する省庁やプログラムはそれぞれ違った目的をもって行っている。

	Contributors	***Primary Aim of Industrial Contribution***
Agencies	DARPA	• Use commercial sector to 'pre-select' defense technologies
	NSF	• Ensure strong industrial base with capability in defense applications
	DOE	• Ensure technologies developed in government labs are put to effective use and are selected appropriately
	NASA	• Assist commercialization of NASA technologies
Thematic Virtual agencies*	TRP (Technology Reinvestment Program)	• Use commercial sector as a 'filter' for ensuring defense technologies are up to date.
	ATP (Advanced Technology Program)	• Fund 'higher-risk' investments in leading edge technology for commercial applications that may not justify industry investment alone
	SBIR (Small Business Innovation Research Program) STTR (Small Business Technology Transfer Research Program)	• Promote growth of small business in high technology areas

*Note :Although virtual agencies are allocated budgets, these budgets are a part of one (actual) agency's budget (eg. ATP) or compilation of budget of several agencies (eg. TRP)

Technology Transfer System - II - Direct Industry Funding

Of $2.7 billion total government IT funding in 1995, we estimate approximately $1.2 billion went to industry, 74% of which was distributed through DARPA, NASA, DOE and the NSF.

全体で$27億の95年の政府IT研究開発支出の内、約$12億が産業へ向けられたと見積られ、更にその74%はDARPA、NASA、DOE、NSFから出資された。

Agencyの性格付けできるかな…

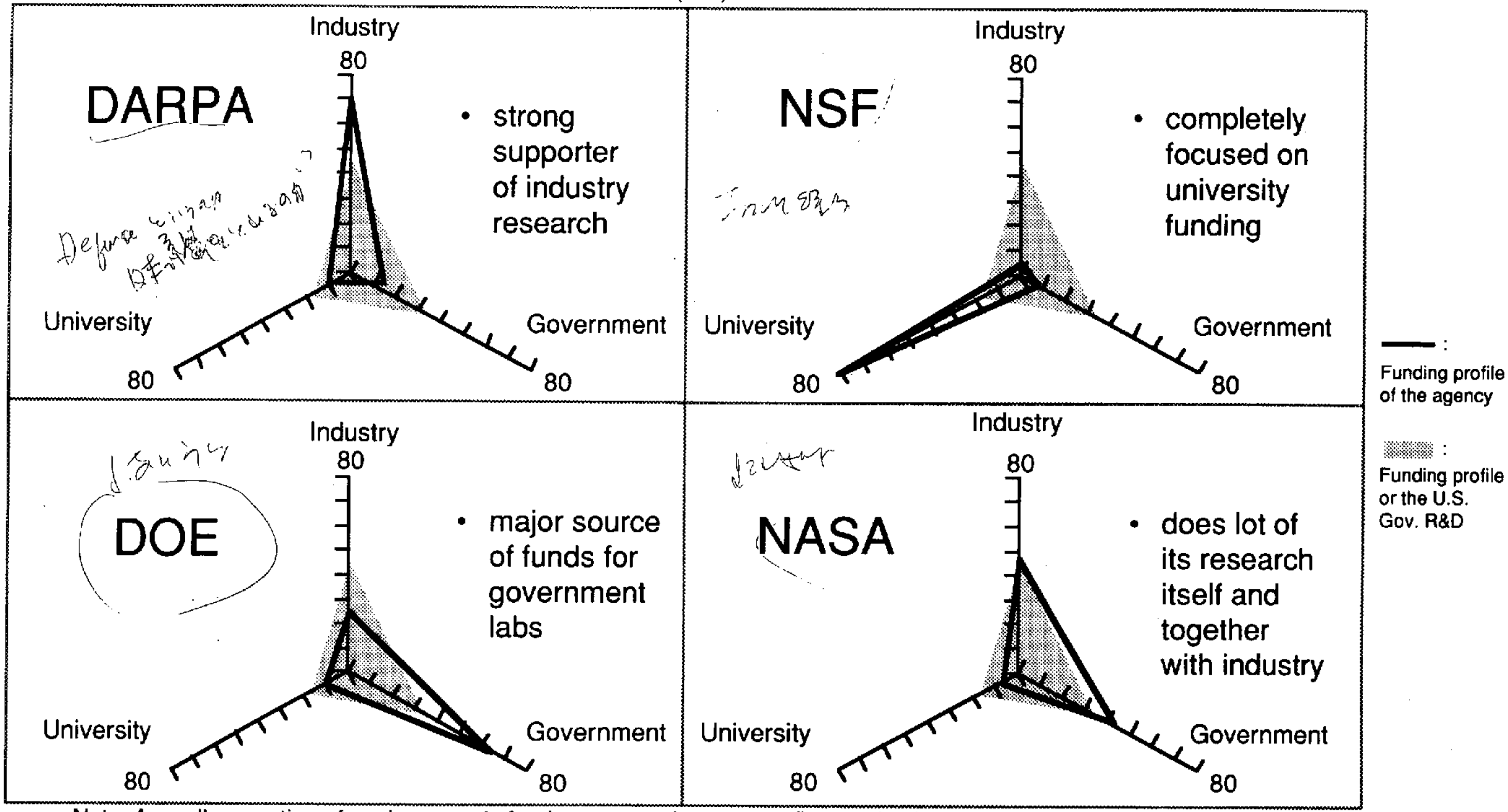
Agency	***IT Funding*** ($M)	***Industry %***	***Monies directed to industry*** ($M)
DARPA	747	70%	523
NASA	328	46%	151
DOE	320	25%	80
NSF	297	5%	15
Others	979	44%	433
Total	2,671		1,202

Source: Arthur D. Little Estimates, NSF survey & Federal Funds

The four big contributors to industrial IT R&D differ widely in their policies of allocation to industry.
4省庁は、産業への出資割当について、全く違う方針を持っている。

Distribution of funding By Sector

(%)



DARPA
- strong supporter of industry research

NSF
- completely focused on university funding

DOE
- major source of funds for government labs

NASA
- does lot of its research itself and together with industry

Note: A small proportion of each agency's funds goes to other non-profit organizations not shown on this chart

DARPA and NASA tend to favor approaches with less government involvement in the work itself, such as grants and direct procurement.

DARPAとNASAは、資金提供(Grant)や直接調達といった政府介在の少ない出資方法を主に取っている。

- DARPA and NASA tend to follow the philosophy that a company needs to be able to make research and development successful under its own management if it is to be able to make the R&D work as products in a commercial market place
- To prevent industry seeing government dollars as a bonus, however, DARPA and NASA usually impose 'cost-sharing'(>50%) obligations on project winners

Companies receiving grants from DARPA's ITO (Information Technology Office) in 1995*

Aerospace Corp.
Applied Parallel research Inc.
AT&T Bell Labs
Bolt, Beraneck, Newman Inc.
Bell Atlantic Federal Systems
Bellcore
Boeing
Computational Logic Inc.
Convex Computer Corp.
Corporation for National Research Initiatives
Cray Research
Dragon Systems Inc.
Enterprise Computing Institute
Environmental Research Institute of Michigan
Financial Services Technology Consortium
FTL Systems
Honeywell
Hughes Aircraft Company
IBM Corp.
Institute for Defense Analysis
Integrated Sensors Inc.
Intel Corp.
Intermetrics Inc.
Kestrel Institute
Litton Guidance and Control Systems
Lockheed Martin
Loral Defense Systems
MasPar Computer Corp.
Microelectronics and Computer Technology Corp.
Mercury Computer Systems Inc.
MITRE Corp.
MPC Corp.
Myricom Inc.
National Semiconductor
Odyssee Research Associates Inc.
Open Software Foundation Inc.
Optivision Inc.
PRC Inc.
Reliable Software Technologies Corp.
Science and Technology Associates Inc.
Software Options Inc.
Sprint
SRI International
TASC Inc.
Teknowledge Federal Systems
Tera Computer Company
Transarc Corp. Tuxedo
Trusted Information Systems
Virtual-Machine Works Inc.
Xerox PARC
Zycad Corp.

* Please see Appendix for full list of DARPA's ITO-sponsored research projects in which these companies are involved

Much of the money available to industry is distributed through a few key government - backed 'virtual agencies' , including the TRP, ATP, SBIR and STTR.

産業への出資の多くは、幾つかの政府のプログラムを通じて行われ、その代表的なものはTRP(Technology Reinvestment Program)、ATP(Advanced Technology Program)、SBIR(Small Business Innovation Research Program)、STTR(Small Business Technology Transfer Program)である。

- The TRP was the government's original vehicle for promoting the concept of industry matching of government funds for 'dual-use' technology
- As the TRP has lost favor, however, its role is being undertaken by the JDUPO, whose future is still unclear.
- In contrast to the TRP, the ATP, which was begun in 1990 and has received dramatically increased funding since then, selects projects solely for their commercial value.
- The SBIR, initiated in 1982 and authorized until 2000, ensures that a proportion of TRP funds always go to small business.
- The STTR, set up in 1992 and modeled on the SBIR, aims to ensure that some of the money set aside for cooperative agreements is available to small companies.

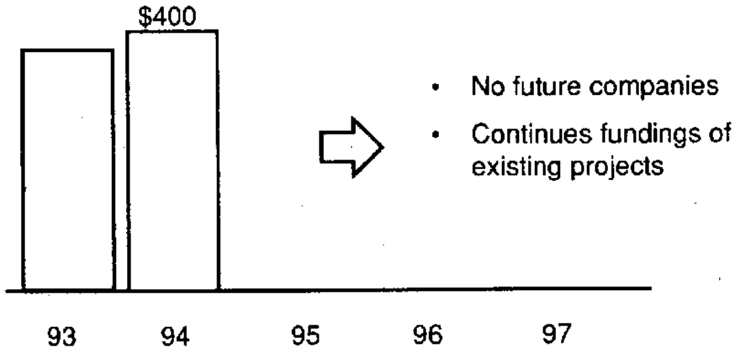
Direct Industry Funding Virtual Agencies

TRP	- Technology Reinvestment Program
JDUPO	- Joint Dual-Use Project Office
ATP	- Advanced Technology Program
SBIR	- Small Business Innovation Research Program
STTR	- Small Business Technology Transfer Program

The TRP was the government's original vehicle for promoting the concept of industry matching of the government funds for 'dual-use' technology.

TRPは軍事と民生両用の技術について、産業との共同出資を進めた最初のプログラムであった。

TRP Appropriation



- No future companies
- Continues fundings of existing projects

Mechanism and Relevance to IT

- Open competition
- Peer review judgment process combined with defense expert judgment
- Only a few programs directly related to IT

- The TRP (Technology Reinvestment Project) was initiated in 1993 as a result of a growing realization that many defense technologies developed in-house were already obsolete by the time they realized practical fruition.
- The TRP was therefore set up to promote the 'dual-use' idea - ie. technologies with applications in both defense and the commercial sector.
- The TRP's approach was to try to choose defense technologies using a commercial 'filter' - in theory if the commercial sector is behind a technology it is more likely to receive development support and advancement over and above government-funded work alone.
- The program has received widespread criticism, however, including the claim that the program was a means for companies to find defense markets for projects which would not be viable on entirely commercial funding.

As the TRP has lost favor, however, its role is being undertaken by the JDUPO, whose future is still unclear.

TRPはその役割を終えたが、それはJDUPO(Joint Dual-Use Project Office)に引き継がれ、その行方ははっきりしない。

JDUPO

Memorandum of Understanding participants

Office of the Secretary of Defense

DARPA

Army

Navy

Air Force

No civilian agency participants previously part of TRP

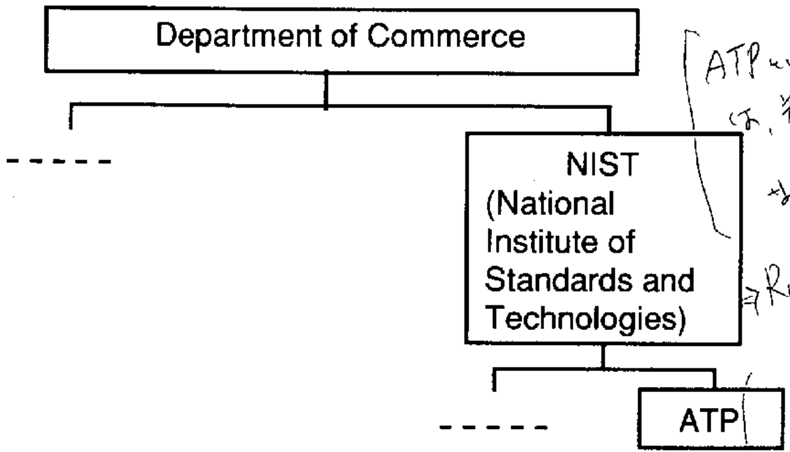
- The JDUPO (Joint Dual-Use Project Office) was established in December 1995 with a Memorandum of Understanding between key government defense interests after the TRP lost support in the 104th Congress
- The key purpose of the JDUPO is:
  - to provide a funding vehicle for projects currently receiving funding under the TRP
  - to maintain support for the 'dual-use' concept
- Future levels, focus and probability of future funding are as yet unclear; however, the JDUPO has stated its intention to finalize plans in 1996 for a 1997 open competition along the lines of the TRP (but there will be no competition in 1996 itself)

Technology Transfer System - II - Direct Industry Funding

In contrast to the TRP, the ATP, which was begun in 1990 and has received dramatically increased funding since then, selects projects solely for their commercial value.

TRPとは対照的に、90年に始まったATPはその後出資額を大きく増やしている。ATPではその技術の商業化だけを基準にプロジェクトが選択される。

Administration



Department of Commerce

NIST (National Institute of Standards and Technologies)

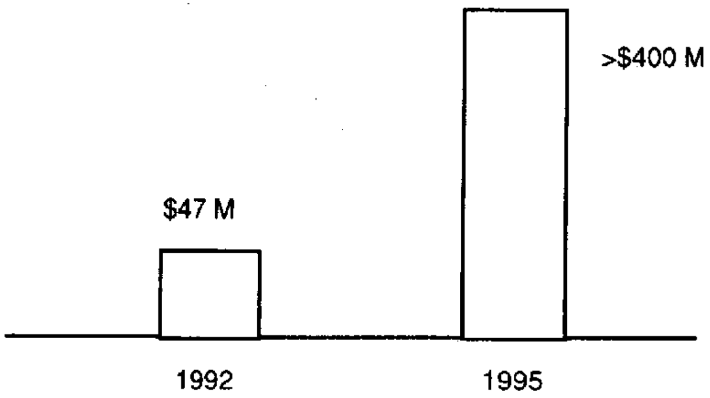
ATP

ATPという仕組みは、参考になるのでは、

→Ruleが良い

お金もあり形を保っている…

Appropriation

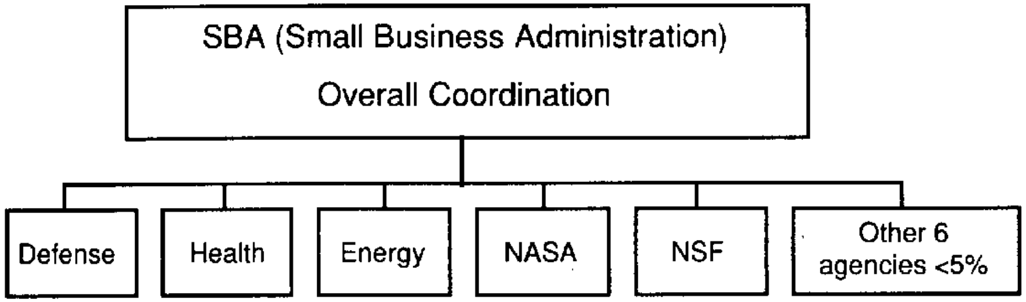


- The ATP's (Advanced Technology Program) mission is broadly defined as 'to provide support for civilian technologies in the nation's economic interest'. Its legislative mandate is defined somewhat differently as 'commercializing new scientific discoveries rapidly' and 'refining manufacturing practices'.
- It specializes in providing financial support for high-risk technology R&D which may not otherwise receive commercial funding
- The ATP approach is characterized by several distinctive features:
  - industry proposes and manages all projects
  - industry participants pay more than half of the total costs
  - following formal peer review, proposals are assessed for likely 'economic impact' by academic and government specialists

The SBIR, initiated in 1982 and authorized until 2000, ensures that a proportion of TRP funds always go to small businesses.

SBIRはTRP予算の一定の部分が小企業へ向けられるようにするものである。82年に設立され、2000年まで承認されている。

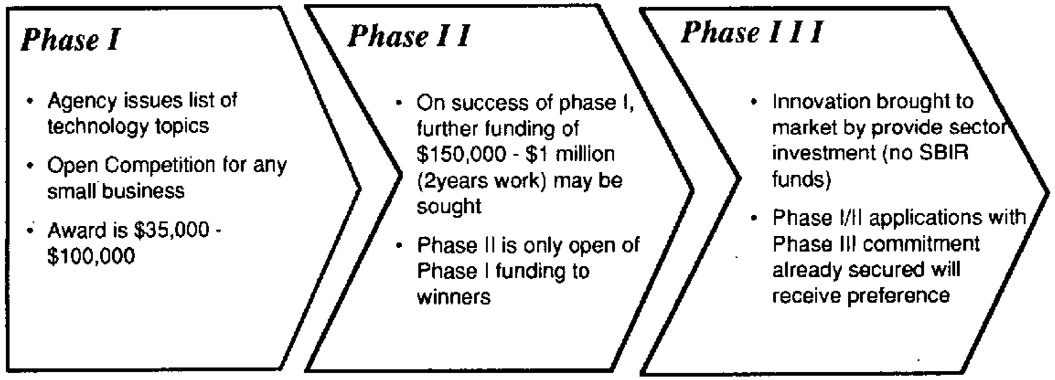
Organization and Management



SBA (Small Business Administration)

Overall Coordination

Funding process



Phase I

- Agency issues list of technology topics
- Open Competition for any small business
- Award is $35,000 - $100,000

Phase I I

- On success of phase I, further funding of $150,000 - $1 million (2years work) may be sought
- Phase II is only open of Phase I funding to winners

Phase I I I

- Innovation brought to market by provide sector investment (no SBIR funds)
- Phase I/II applications with Phase III commitment already secured will receive preference

中小企業にも、お金が回る仕組をつくっている…

- The SBIR (Small Business Innovation Research Program), total appropriation around $1 billion, was established by the Small Business Innovation Act in 1992, which has since been amended twice to extend the program up to the year 2000
- The SBIR is a stand-alone project, although some proposals were selected submitted as part of the TRP general solicitations (approximately $200 M)
- The goal of the SBIR is to ensure that 1.25% of R&D funds form each of the 11 agencies participating in industrial cooperative R&D are set aside for small businesses (determined by industrial classification of employees and competitive relationship with other companies in the same industry)

The STTR, set up in 1992 and modeled on the SBIR, aims to ensure that some of the money set aside for cooperative agreements is available to small companies.

STTRはSBIRをモデルとして、協同契約の予算の一部が小企業に向けられるようにしたプログラムである。92年に設立された。

Coordination

SBA (Small BusinessAdministration)

5 agencies only

Defense Health Energy NASA NSF

Funding process

Phase I

- Agency issues list of technology topics
- Open Competition for any small business
- Award is $35,000 - $100,000

Phase I I

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Phase I I I

- Innovation brought to market by provide sector investment (no SBIR funds)
- Phase I/II applications with Phase III commitment already secured will receive preference

- The STTR (Small Business Technology Transfer Program) was modeled on SBIR, but projects must involve a small company and a university/federally - funded R&D center/or non-project institution
- Set up in 1992 as a three-year pilot beginning FY 1994
- Organization and selection process closely follows the SBIR pattern
- Each of the five agencies with extramural R&D fundings budgets greater than $1 billion were required to set aside 0.05% of their extramural R& D budgets in 1994, 0.10% in 1995, and 0.15% in 1996. Total (1996) appropiation is therefore around $400 million.

Technology Transfer System - II - Direct Industry Funding - BBN Case Example

BBN (Bolt, Beraneck, Newman Inc.) is a good example of a company directly funded by industry clearly contributing to the public good.

BBN(Bolt, Beraneck, Newman Inc.)社は、私企業が政府から出資を受けて研究開発し、国民の役に立ったという良い例である。

BBN Case History

- Initially funded by DARPA to develop the packet-swtching router technology for 'ARPANET'
- Although the company itself had some difficulties when it attempted to market its products to the wider public, the network it helped create formed the foundation of the Internet, which arguably has improved (and will impr~~ove) the lives~~ of millions across the globe
- BBN itself was turned-around after further venture capital funding, and is now in the latter stages of development of a 'multigigabit' Internet router due for launch in 1997 (which received further DARPA funding)

- The BBN case history clearly demonstrates how the 'system', rather than individual companies, benefits from direct industry funding
- The key output of the BBN funded product development was (eventually) the Internet, rather than huge glory for BBN, which remains a small company

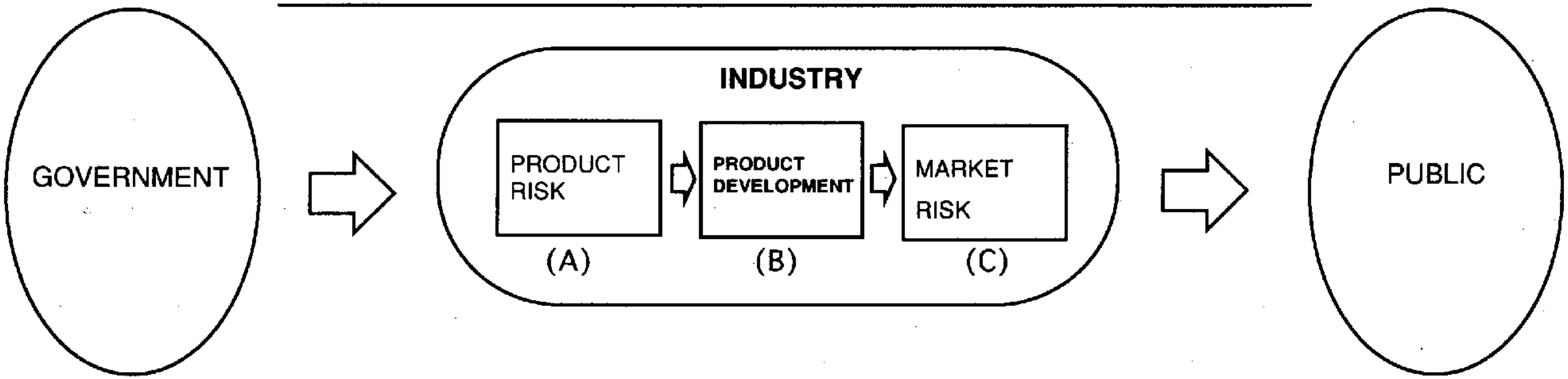
経済の裏付
はあるが!...

The public receives the eventual benefit of government direct funding of industry R&D. Government money is not a bonus to industry; industry must make a considerable additional investment to realise the value of government support.

産業への政府資金の出資は、最終的に国民の役に立つものだが、その過程で企業をただ儲けさせている訳ではない。なぜなら研究開発結果を商業化し利潤を出すまでには、企業の側で相当の追加投資が必要だからである。

Industry investment required to advance government-funded R&D to commercialization

ここがないと Commercialization はできない…



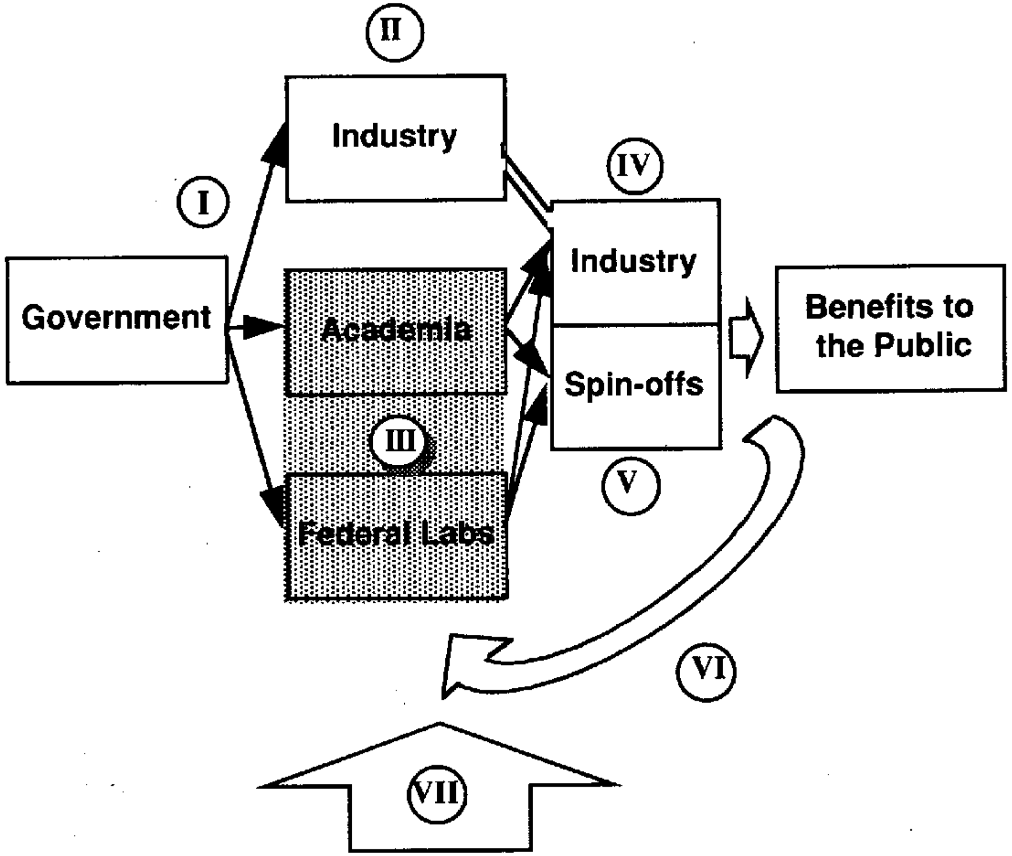
(A) Usually government funding is of high-risk technology with some distance from commercialization; Industry may require investment even to get to the product developmet stage

(B) Product development for commercialization requires significant investment & effort

(C) Market risk is born by industry

どういう意味

Productivity of university and federal laboratory research is ensured by straightforward economic incentivization.
大学と国立研究所での研究活動は、経済的インセンティブによりその生産性が保たれている。



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確保ている

The Economic Incentives for an academic/federal researcher

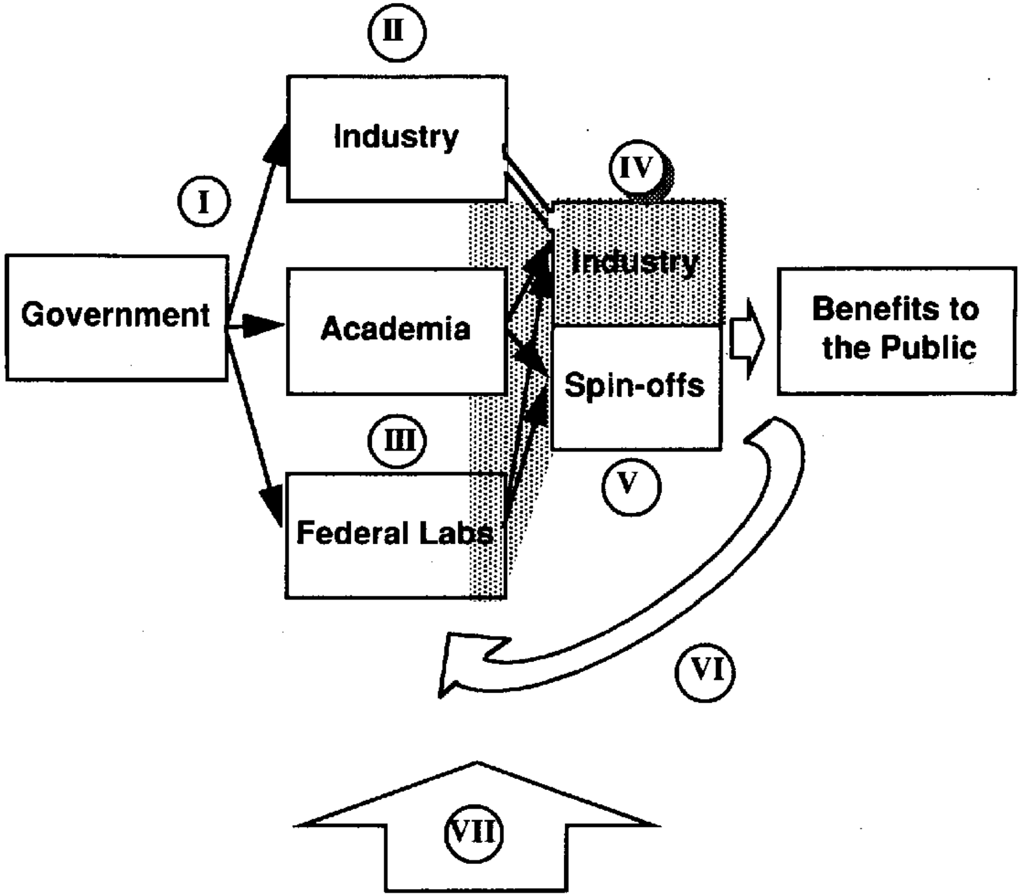
- A researcher's salary, promotion prospects, and prospects of tenure* all depend directly on the quality of his work as judged in 'peer reviews'.
- Most university researchers' salaries cover only nine months of the year, forcing them to fund the rest out of the research budgets of research projects they must win themselves

→ こういった危機感を持っているのか??
(給料の量ではなく)

- In cases where research is successfully commercialized, researchers can receive up to 1/3 of royalties or license fees

* A 'lifetime employment' system for academics which guarantees them a post and (some) funds - attained only after proof of excellence

Industry/Academic research cooperation is in widespread use and cooperation takes place at various levels.
産学連携は今や広く行われており、色々なレベルでの連携がある。



Technology Transfer System - IV - Industry/Academic Cooperation

The line between a research institution's role in commercialization and industry's is clearly drawn.
技術の商業化における大学・研究所と産業との役割分担は、大変はっきりと線が引かれている。

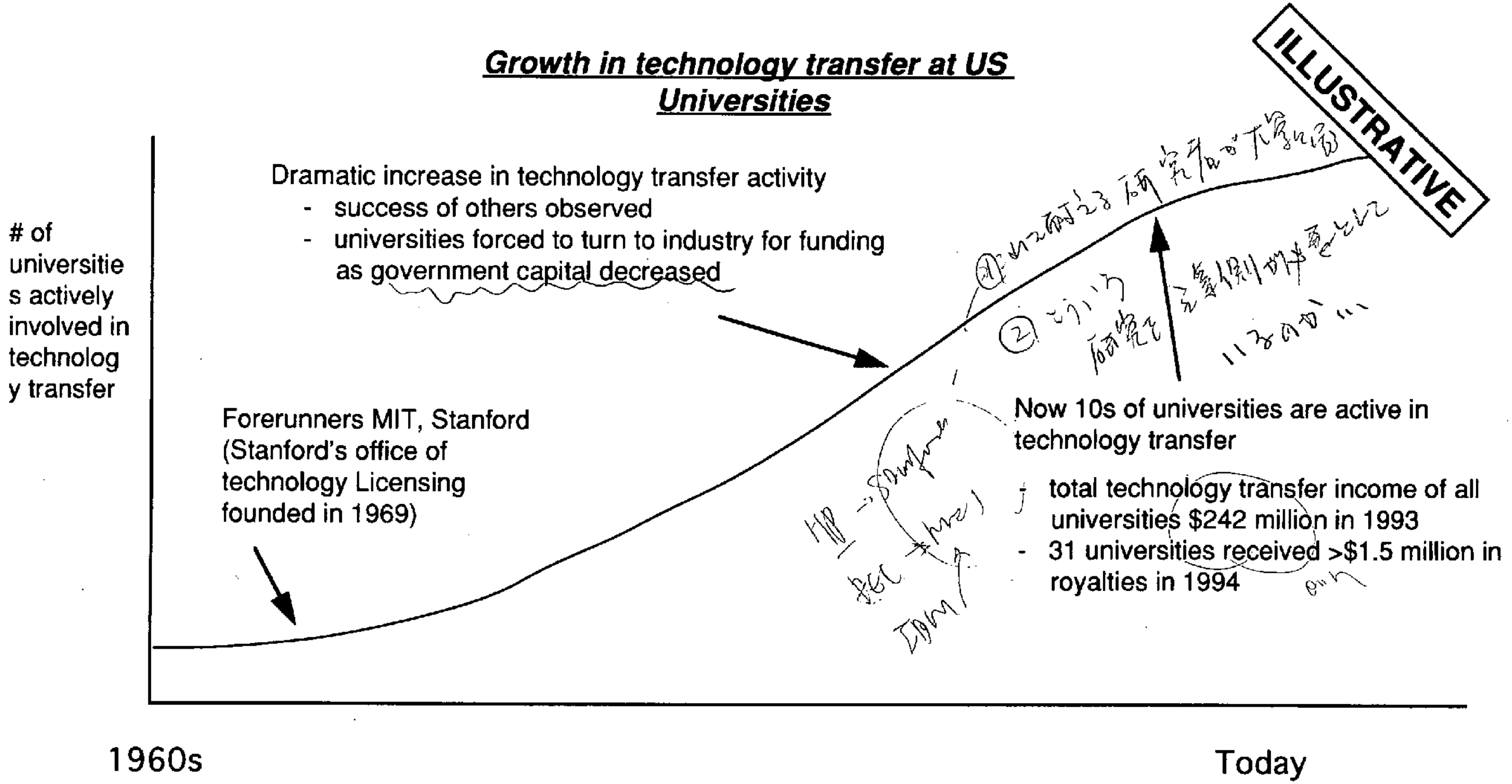
ここにはResponsibilityは無い。

The role/responsibilities of Universities/Federal Laboratories	The role/responsibilities of Industry
• Research	• Development (product development)
• Fundamental knowledge building	• Particular products/services
• Free thinking	• Solutions to real problems
• Non-commercial, not-for-profit	• Production and distribution of goods
	• Commercial, profit-making, taxable

It is therefore clear that responsibility for commercialization lies in the domain of industry

After realizing the benefits to be gained from cooperation with industry, first Stanford and MIT and then other universities have established strong technology transfer capabilities.

産学連携の利益がStanfordやMITの先例により認識されると、各大学はこぞって産学連携、技術移転の努力をするようになった。



Growth in technology transfer at US Universities

Forerunners MIT, Stanford (Stanford's office of technology Licensing founded in 1969)

Dramatic increase in technology transfer activity
- success of others observed
- universities forced to turn to industry for funding as government capital decreased

Now 10s of universities are active in technology transfer
- total technology transfer income of all universities $242 million in 1993
- 31 universities received >$1.5 million in royalties in 1994

①企業に研究する研究者が大学に居る

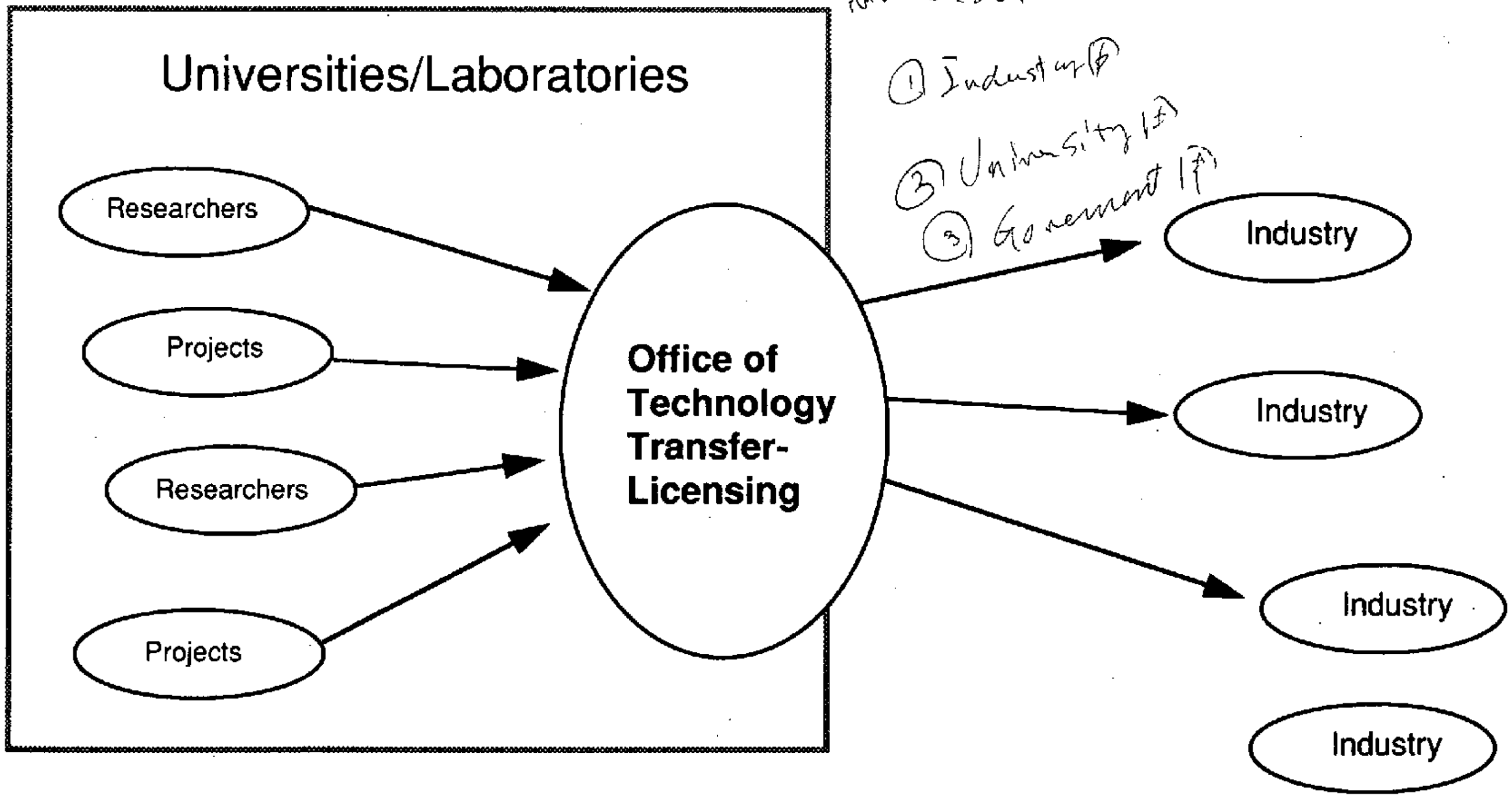
②こういう研究を企業側が必要としているのが…

HP – Stanford
DEC – Harvard
IBM

Most universities and government laboratories have created offices for technology transfer, and pro-actively market technologies to industry.

各大学や国立研究所では、技術移転／ライセンス事務所を設置し、産業に向けて技術を積極的に売り込んでいる。

窓口が出まとめ、いる



① Industry (民)
③ University (学)
③ Government (官)

Inbound

- Collects 'invention disclosures'
- Assesses marketability
- Files intellectual property
- Maintains technology portfolio

Outbound

- Markets technologies
- Negotiates licenses
- Matches industry interests and technologies

Coordination at focal point

The benefits for both academia and industry are significant.
産学連携では、大学・研究所と産業の両方に大きな利益がある。

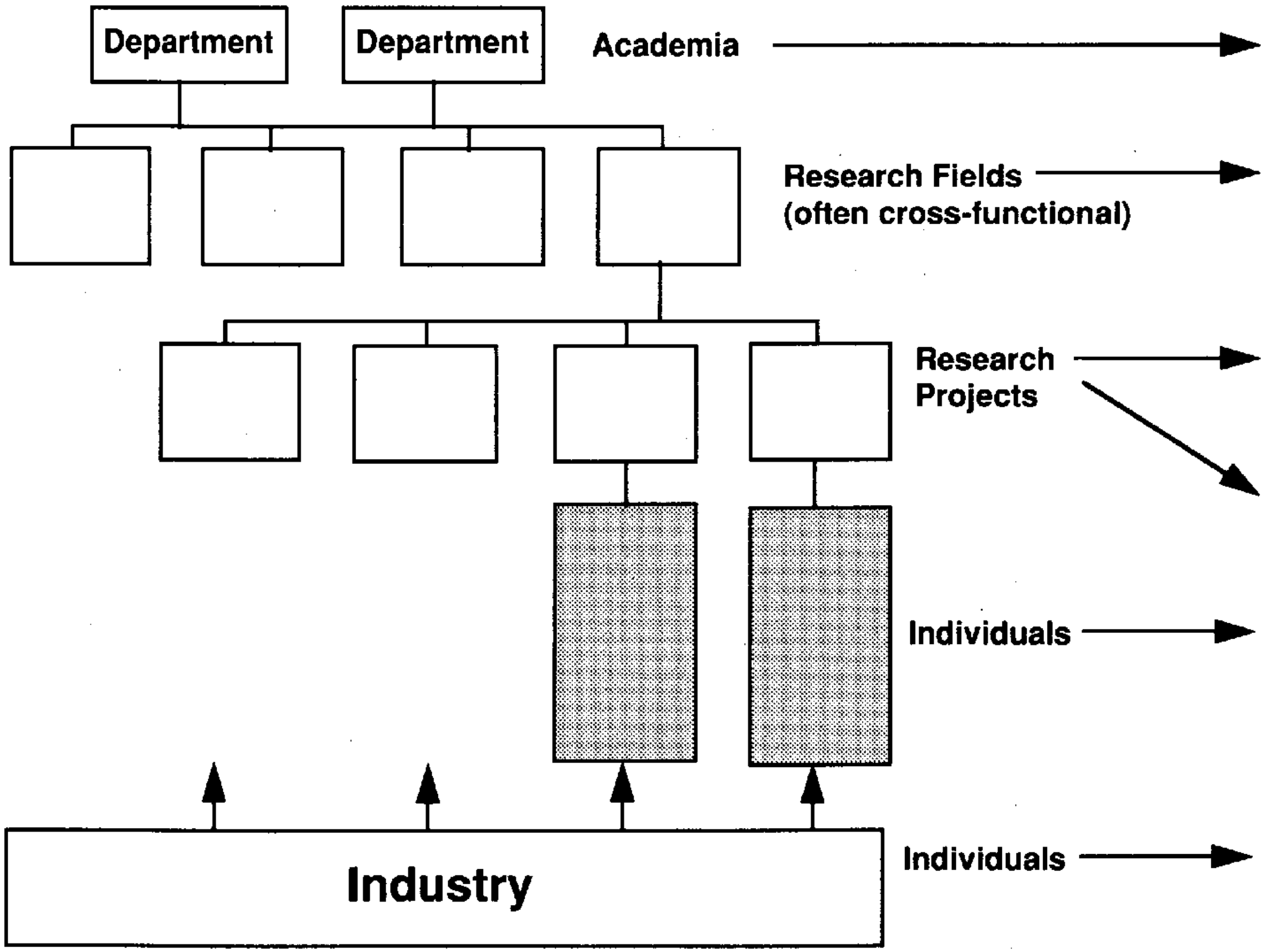
Benefits for Academia

- Direct link with additional sources of funds
- Better understanding of 'what's hot and what's not' (at least in terms of immediate commercial potential)
- Prestige (from successful collaboration)

Benefits for Industry

- Can more quickly access the results of research
- In a better position to negotiate license/ intellectual property rights
- Better contact with researchers, potentially for recruiting
- Prestige (from successful collaboration)

Cooperation takes place at various levels within universities.
産学連携は大学の様々なレベルにおいて行われている。



Academia → 'Industrial Liaison Programs'

MITには、この専門の事務室がいた。
(会って話をした)。

'Industrial Liaison Programs'
- General introductions between companies and research/researchers in various fields

Research Fields (often cross-functional) → 'Industrial Affiliate Programs'

'Industrial Affiliate Programs'
- Capital sources put together with researchers and technological results in particular technical fields

Research Projects → 'Sponsored Research', 'CRADAs (Cooperative Research and Development Programs)'

'Sponsored Research'
- Capital providers give money direct to particular research programs

'CRADAs (Cooperative Research and Development Programs)'
- Formalized process for joint research efforts

Individuals → 'Consulting'

'Consulting'
- Academics' part-time personal businesses, typically up to 20% of time

Individuals → 'Loan Researchers'

'Loan Researchers'
- Researchers 'loaned' from companies to research projects

CRADAs (Cooperative Research and Development Agreements) are the technology transfer mechanism of choice for federal labs, but are little used by universities.
国立研究所では産業との連携の形態としてCRADAが最も使われるが、大学ではほとんど使われていない。

- a legal entity for joint funding of research by universities/laboratories and industry
- frequently used for joint product development of industry and laboratories
- lab provides facilities, personnel, and equipment, and all of this may partly be financed thorough a special grant
- industry also provides funds etc.
- very flexible structure leaves lots of room for customization to individual labs

➡ very popular because of flexibility

➡ often a thinly disguised purchase order in which an agency gives money to a lab to buy a computer and fund lab and company product development

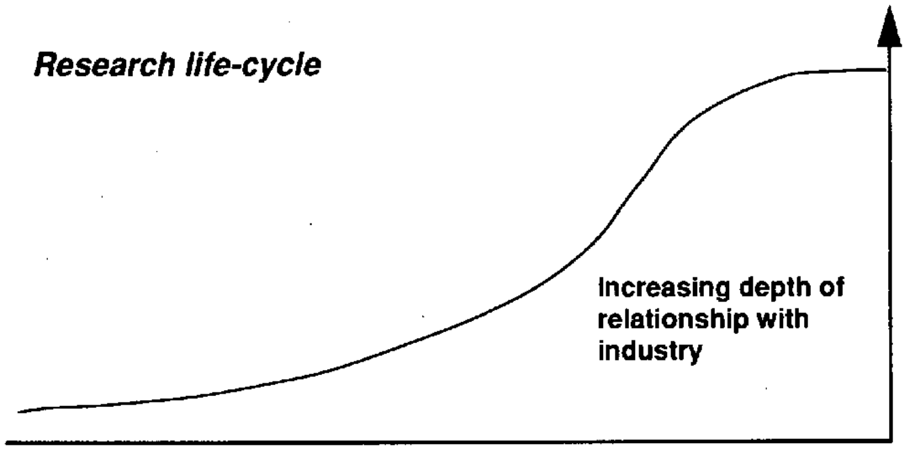
➡ CRADAs are often effective because they put labs into the position of a demanding buyer who is intimately included in the product development process

➡ in practice, the 200 or so in operation are restricted to federal labs and have little application in university technology transfer

Universities must maintain a balance of research at different stages of the 'life-cycle' and manage their relationship with industry accordingly.

大学はその色々な段階にある技術群のバランスを保つためにも、産業との関係を維持する必要がある。

大学に対するmessageではあるが
→ 方法論は形骸化しかねない。



Theoretical	Theoretical systems	Experimental	Applications
• New ideas/broad themes/approaches without necessarily any application • 'Pencil and paper' research • Industry unlikely to be involved	• Theory lends itself to theoretical areas: new concepts and ideas are set in context • Ideas for tangible applications begin to develop • Industry maintains a 'watching brief', often though 'awareness briefings' organized by universities	• Practical applications put to the test in the laboratory • Industry may be involved in co-funded projects	• Product development arising out of original ideas may be entirely in industry domain • Sub applications and branch-topics develop • Researchers involved throughout the life-cycle may move into the industrial domain

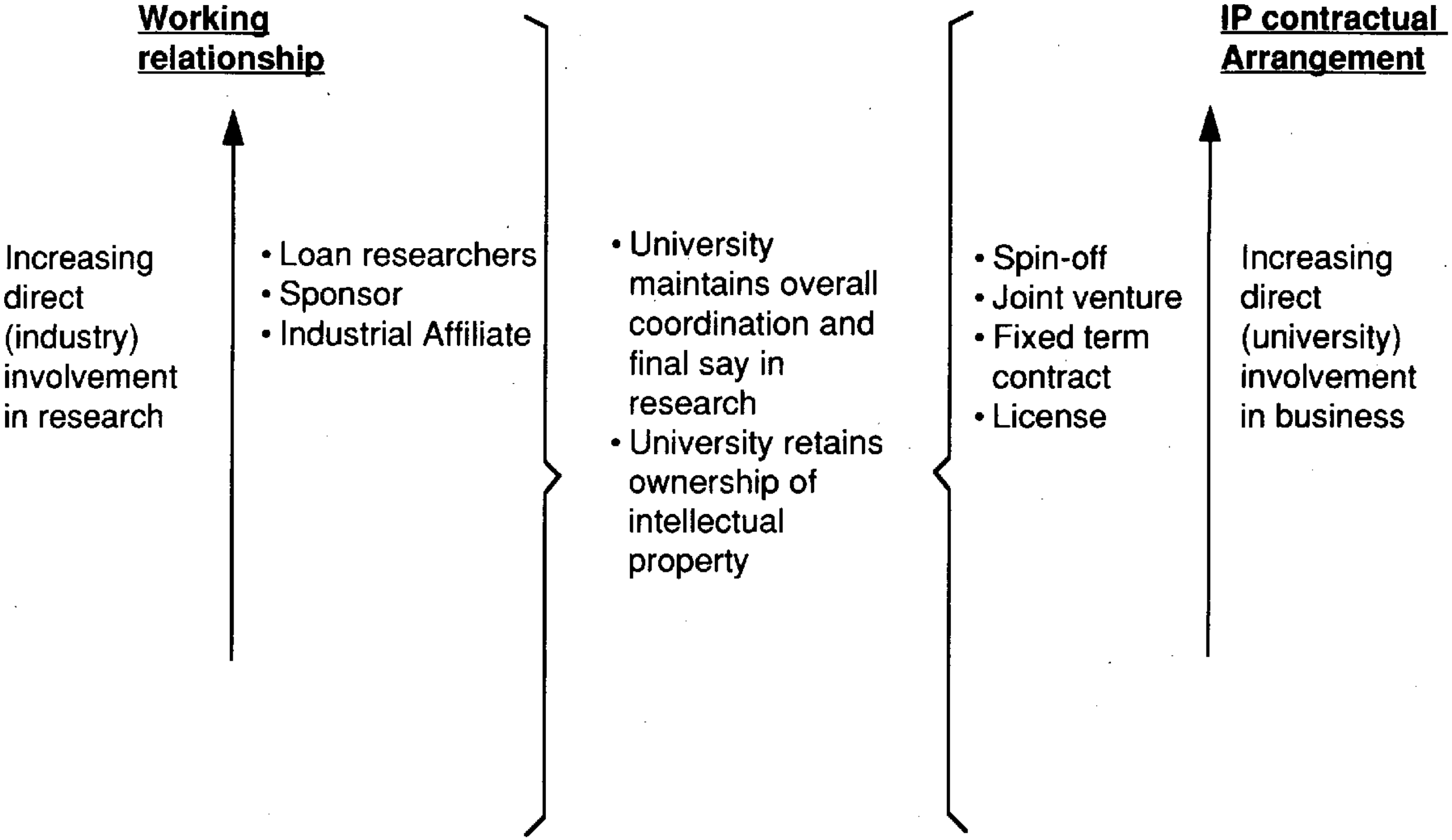
Typical research theme 'life-cycle' ~20 years →

→ 個々による
20年は長い

- In order to ensure commercializable ideas in 10 - 15 - 20 years time, universities must ensure a balance of more basic knowledge-generation-type research is undertaken together with more readily commercializable work
- To ensure suitable partners can be found as research themes mature and approach commercialization universities must keep in contact with and share information with a variety of companies during the life-cycle
- Universities maintain this balance by
  - holding regular focus meetings to maintain perspective on long term 'package' or portfolio of research
  - maintaining a contact database of companies which are kept in touch with research topic developments and progress

Whichever mechanism of cooperation is employed, intellectual property and research ownership usually remains the domain of the university.

どのような連携の形態を取ったとしても、研究開発の主導権と結果の知的所有権は大学に属するのが慣わしである。



Working relationship

Increasing direct (industry) involvement in research

- Loan researchers
- Sponsor
- Industrial Affiliate

- University maintains overall coordination and final say in research
- University retains ownership of intellectual property

- Spin-off
- Joint venture
- Fixed term contract
- License

IP contractual Arrangement

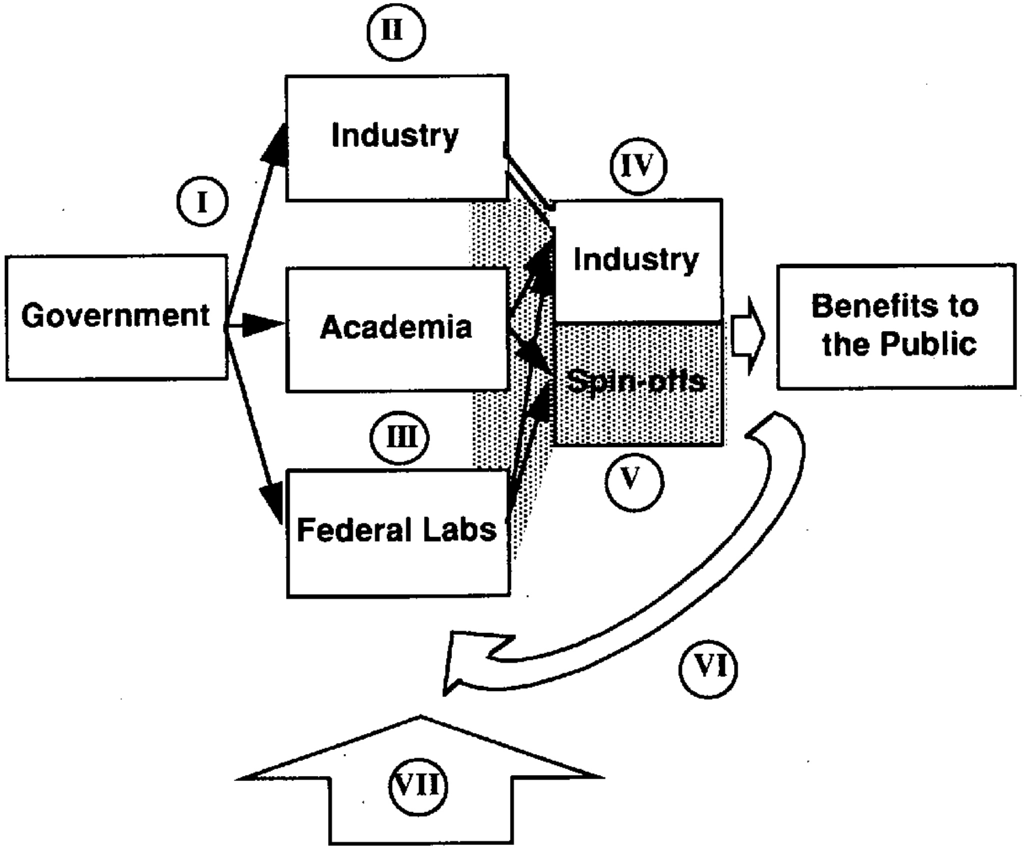
Increasing direct (university) involvement in business

Technology Transfer System - V - Spin-offs

（（ [illegible]、コレ、Sillicon Valley はこれ。））

Spin-offs are one of the key features of US technology transfer, and are an extremely effective means of transferring information rapidly and accurately into the private sector.

スピンオフは米国での技術移転の1つの重要な形態であり、移転から商業化においての速度が速く、効果的・効率的でもある。



Nestor も
このひとつと言えるであろう…

Spin-offs are one of the key features of US technology transfers, and are an extremely effective means of transferring information rapidly and accurately into the private sector.
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- Spin-offs are one of the most important mechanism in US technology transfer, particularly in IT
- In many cases, even when research is successful universities do not have the connections or the resources (or may not deem it of a high likelihood of success) to push it into the commercial world
- Individual researchers, with a belief in the fruits of their own research, license the technology directly, and found their own companies
- The belief in this possibility, and the existence of highly successful examples in the IT industry today, are strong motivation for researchers
- In many cases, researchers are simply unaware of the high risk /reward ratio of start-up companies like a national lottery, the fact that the odds are stacked against you does not necessarily deters you from taking part.

賭け。　つみ積なっている

Many of today's major IT companies initially emerged as spin-offs.
IT産業の相当数の現有名企業は、最初はスピンオフとして始まった。

ILLUSTRATIVE*

実例

Company name	School	Year
Hewlett-Packard	Stanford	1939
Digital Equipment Corp.	MIT	1950s
Informix	Berkeley	1980
Silicon Graphics	Stanford	1982
Sun Microsystems	Stanford	1982
Sybase	Berkeley	1984
Cisco Systems	Stanford	1984
Aldus	Washington	1984
Carnegie Group, Inc.	CMU	1984
Wolfram Research	Illinois, Caltech	1987
Transarc Corporation	CMU	1989
Fore Systems, Inc.	CMU	1990
Claritech	CMU	1992
Netscape	Illinois	1994
Agents Inc.	MIT	1995
WebCrawler	Washington	1995
Lycos	CMU	1995

→ 新しいところ
CMU 多い.

* This list is not exhaustive, and includes only a sample of today's 'major' IT companies. Thousands of smaller companies are also in operation.

Funding sources for spin-offs are usually venture capitalists, but recently universities have begun to supply capital themselves.

スピンオフ企業への出資は通常ベンチャーキャピタルが多いが、最近では大学が資金を提供することも始められている。

大学がFundingすることもある…

- Recognizing the importance of start-ups as a means of technology transfer, universities have recently begun to provide venture-capital style funding to start-ups
- As well as increasing the available supply of capital for start-ups, this has increased the technical support that a start-up firm tends to receive after its founding, since the university continues to maintain a close relationship
- Additionally, funding such start-ups is an excellent means for universities to acquire knowledge of what succeeds or fails in the commercial world and why

Lycos: A Case Example

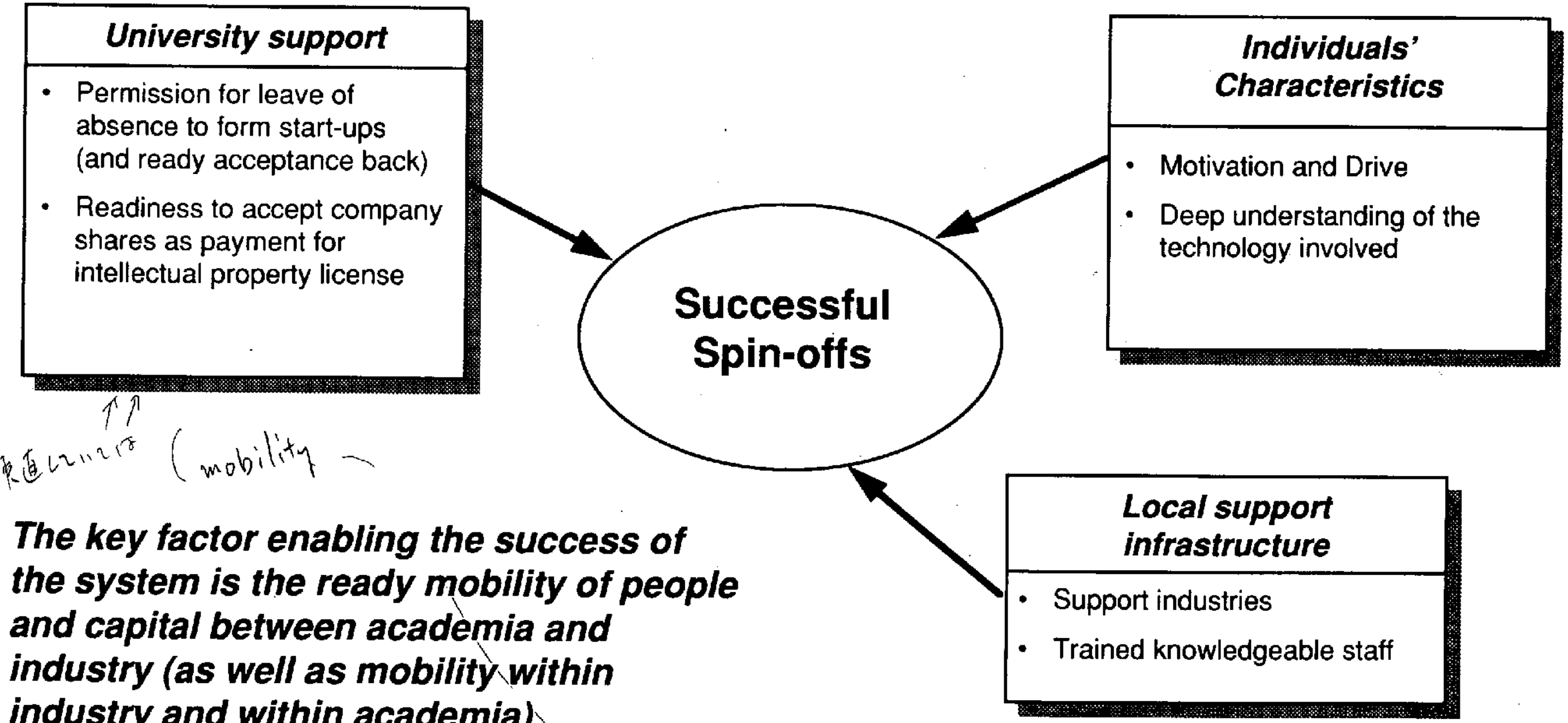
- Funded by Carnegie Mellon University, a group of researchers founded Lycos Inc., an internet search service provider (University owns 20% of equity)
- The company has proved extremely successful and today has revenue of about $0.3 million/month
- The CMU Technology Transfer Office continued to assist through out the start-up process

大学の事業（ビジネス）として実施している

→私立には意味がある

The key factors for success of spin-offs are university support and local infrastructure, as well as individuals' motivation.

スピンオフの成功のためには、個人のモチベーションはもとより、大学のサポートや地域でのサポート基盤が重要な要因である。



University support

- Permission for leave of absence to form start-ups (and ready acceptance back)
- Readiness to accept company shares as payment for intellectual property license

Individuals' Characteristics

- Motivation and Drive
- Deep understanding of the technology involved

Successful Spin-offs

Local support infrastructure

- Support industries
- Trained knowledgeable staff

ここが硬直していては (mobility —

The key factor enabling the success of the system is the ready mobility of people and capital between academia and industry (as well as mobility within industry and within academia)

(力のあるResearcherは 日本の大学にいるべきではない…)

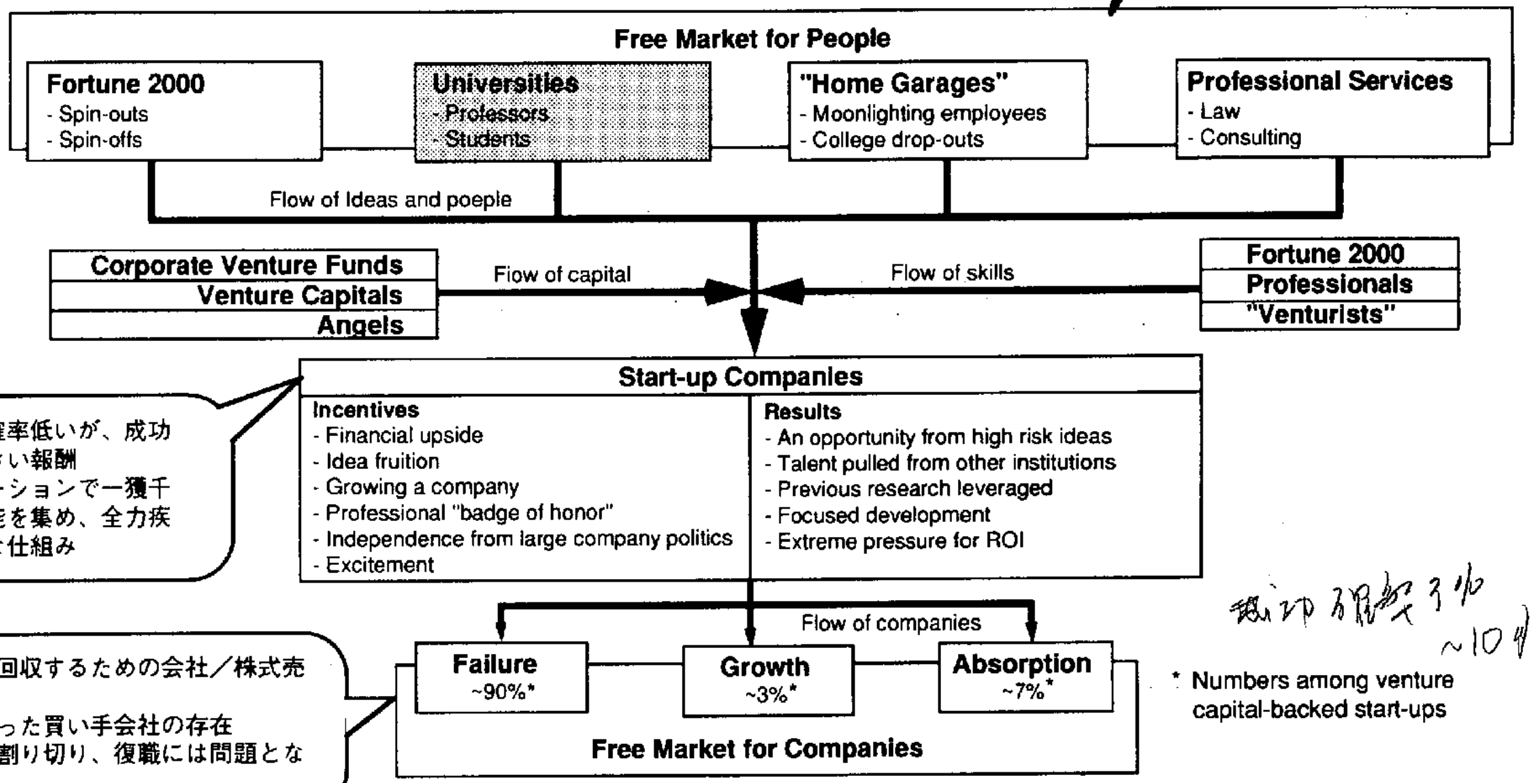
In the community outside of university, an infrastructure of supporting services for spin-offs has developed.

大学周辺の地域では、スピンオフをサポートする色々なサービスを提供するインフラが出来ている。

US Venture Support Infrastructure

- ベンチャーを始めるためのアイディア
- ベンチャーを始めようという人
- 各種スキルを持つ人

が豊富にあり自由流通している



Free Market for People

Fortune 2000
- Spin-outs
- Spin-offs

Universities
- Professors
- Students

"Home Garages"
- Moonlighting employees
- College drop-outs

Professional Services
- Law
- Consulting

Flow of Ideas and poeple

Corporate Venture Funds
Venture Capitals
Angels

Flow of capital

Flow of skills

Fortune 2000
Professionals
"Venturists"

Start-up Companies

Incentives	**Results**
- Financial upside	- An opportunity from high risk ideas
- Idea fruition	- Talent pulled from other institutions
- Growing a company	- Previous research leveraged
- Professional "badge of honor"	- Focused development
- Independence from large company politics	- Extreme pressure for ROI
- Excitement	

Flow of companies

Failure ~90%*

Growth ~3%*

Absorption ~7%*

Free Market for Companies

- 成功は難しく確率低いが、成功すると大変大きい報酬
- 強力なモチベーションで一獲千金を目指す才能を集め、全力疾走させる自然な仕組み

- 成功後、成果を回収するための会社／株式売却市場
- 技術獲得等を狙った買い手会社の存在
- 破産も確率との割り切り、復職には問題とならず

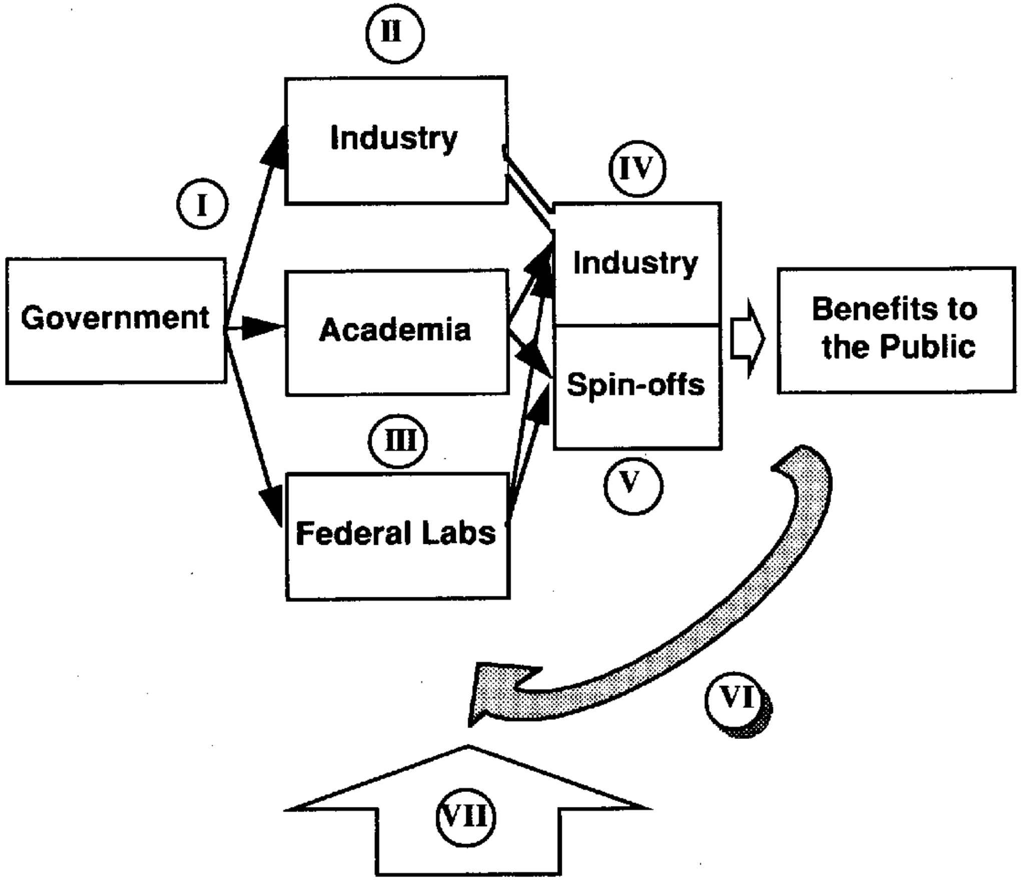
成功確率3%
~10%

* Numbers among venture capital-backed start-ups

Fluid markets of all components of venture business are in place, supporting spin-off activities.

Technology Transfer System - VI - Feedback

The key strength of the process is that technology transfer from universities to industry is complemented by feedback from industry to universities.
産業から大学・研究所へのフィードバックは、技術移転をより向上・促進する重要なものである。



feedbackも必要.
↓
中味は??

Technology Transfer System - VI - Feedback

The key strength of the US technology transfer is that technology transfer from university to industry is complemented by feedback from industry to universities.

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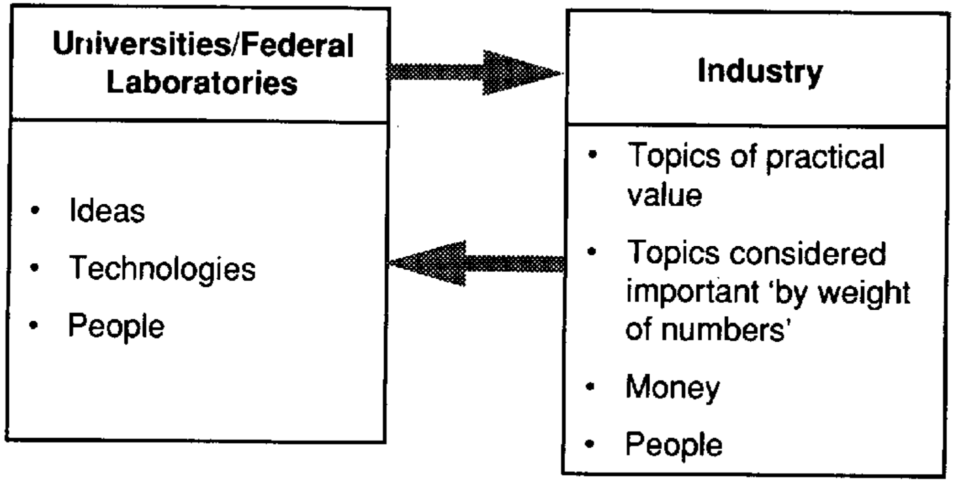


Universities/Federal Laboratories

- Ideas
- Technologies
- People

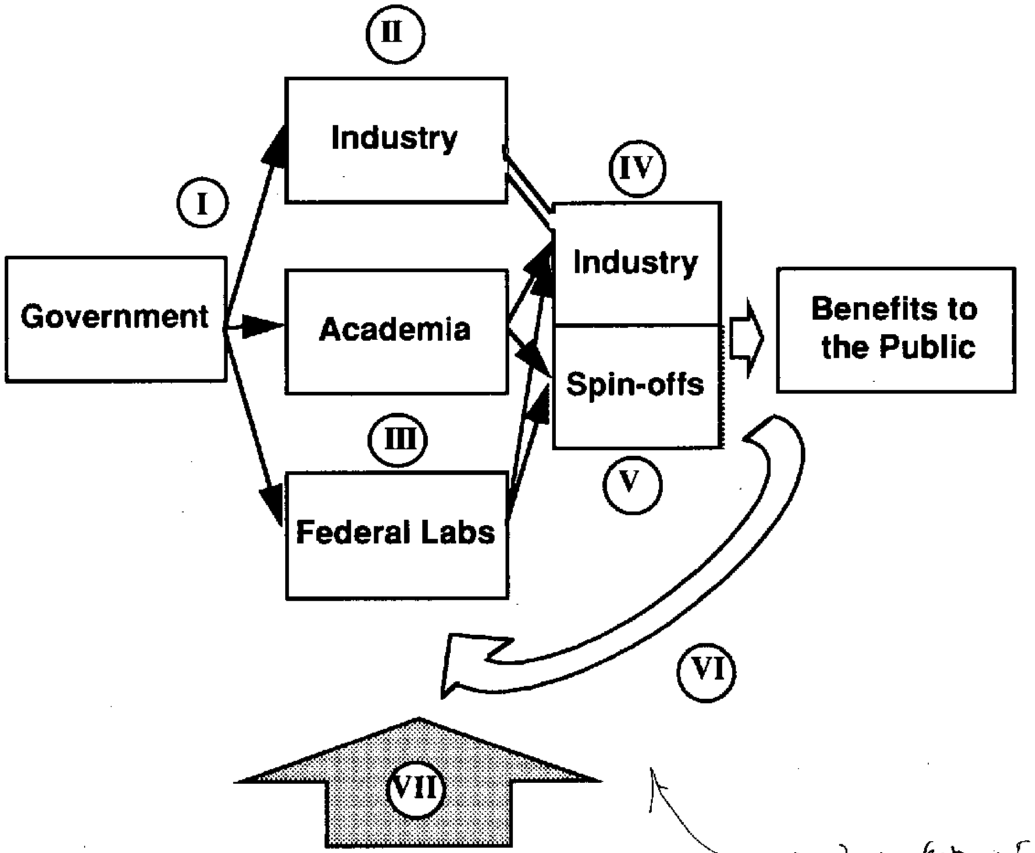
Industry

- Topics of practical value
- Topics considered important 'by weight of numbers'
- Money
- People

- In principle, researchers can choose topics based on their own academic interests
- In practice, however, they can only receive funding for ideas considered meritworthy by a wide audience, including peers and industry
- As government funding has declined and industrial funding has correspondingly increased, the weight of the voice of industry has increased
- An accelerating force has been the trend in government-backed programs such as the ATP to further encourage collaboration

Technology Transfer System - VII - Legal Infrastructure

The system is suported and enabled by a number of key pieces of legislation.
技術移転・実用化の全体の仕組みは、そのための法体系により基盤が作られている。



こういう仕組を支えた法律群...

Since the 1960s, a number of pieces of legislation have been focused on facilitating transfer of intellectual property in general into the public domain.
知的所有権の一般への移転を目的として、60年代から数々の法律が作られてきた。

1966	Freedom of Information Act	・政府の活動を一般に知らせるための仕組みを作った ・省庁の記録を要求し、すぐにそれらを準備させる権利を提供した
1994	Electronic Freedom of Information Act	・1966年のFreedom of Information Actの義務が、電子的記録も含め全ての記録・情報に適用することを確認した ・省庁に対し、全ての情報へのアクセスをオンラインで一般に提供するよう要求した
1995	Electronic Freedom of Information Improvement Act	・上記94年のActの要求がより理解徹底されるよう修正した

政府の方から国民へ
情報をopenにすること（提供する）
はいいかね。

Several pieces of legislation have been aimed specifically at improving the effectveness of technology transfer.

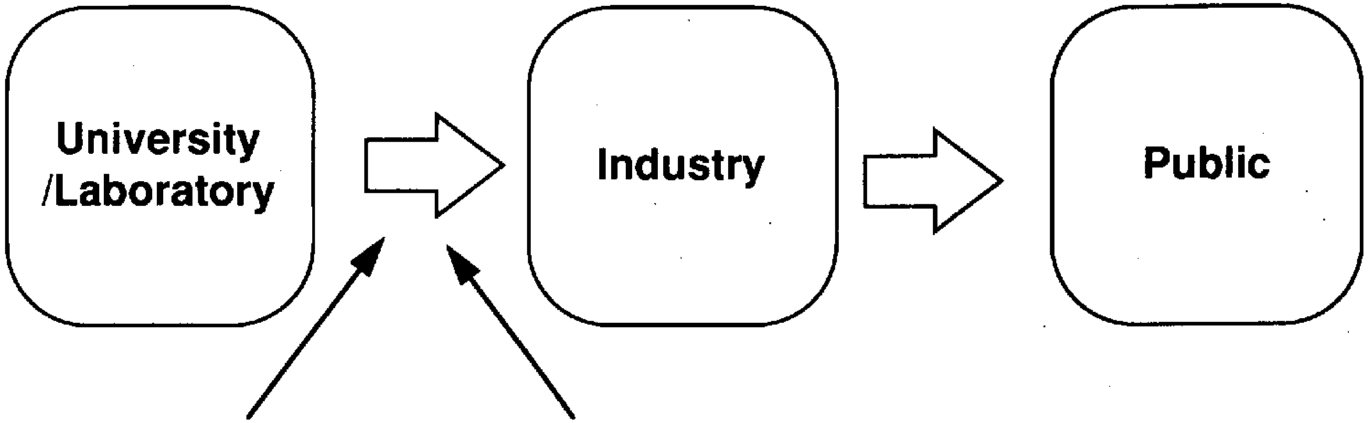
数々の法律が技術移転の効果を高める目的のために作られた。

1980	Stevenson-Wydler Act	・技術の移転を国立研究所の研究員の使命と決めた ・研究・技術応用局(Office of Research and Technology Application)を設立し、政府所有及び政府出資研究の成果・技術の情報公開を推進した
1980	Bayh-Dole Act	・政府のR&D基金によって発明し開発された技術について、発明を行った小企業や非営利団体が知的所有権を持つ権利を与えた ・大学、研究所は、研究ができた成果を自分達のものにできるようになり、商業価値の高い研究を追求するｲﾝｾﾝﾃｨﾌﾞを得た ・さらに大学側はそのかわりﾗｲｾﾝｽやﾛｲﾔﾘﾃｨｰからの収入を教授陣と一部分けあうことができ、実際の研究者に強いｲﾝｾﾝﾃｨﾌﾞが与えられた
1986	Federal Technology Transfer Act	・政府所有・政府運営の研究所に、CRADAの仕組みによる産業との協同研究を許可した ・国立研究所技術移転コンソーシアムを作り、技術移転を研究所の使命と決めた ・技術移転に関して、外国企業に比して米国企業の優先扱いを決めた
1989	National Competitiveness Technology Act	・CRADAの仕組みによる産業との協同研究を、政府所有・委託運営の研究所にも許可した ・CRADAの仕組みによる産業との協同研究において、産業の秘密情報を情報開示義務から保護することを決めた
1991	Defense Authorization Act	・国立研究所と政府出資研究機関に対して、小企業との協同研究活動を成功させる確率が高まる場合、紹介業者と契約することを許可した。
1991	American Technology Preeminence Act	・CRADA参加者同士での知的所有権の交換を許可した ・研究所のディレクターは、余剰の研究機器を教育機関や非営利団体に寄付できるようになった
1992	Small Business Technology Transfer Act	・5つの省庁に対して、小企業、大学、及び研究所の協同研究に対して出資するよう要求した
1993	National Competitiveness Act	・商務庁での民生技術プログラムを強化した ・Stevenson-Wydler Actを修正し、製造技術の開発及び国全体での利用の推進を図った ・商務庁の技術管理への予算割当を承認した

The Stevenson-Wydler Act and the Bayh-Dole Act of 1980 in particular laid the ground work for technology transfer.

80年のStevenson-Wydler法とBayh-Dole法は、特に技術移転の基礎を作った。

Technology Transfer



Stevenson-Wydler Act

- Defined technology transfer as mission of university/laboratory.
- "The government's investment in the laboratories must contribute to US industrial innovation".*

Bayh-Dole Act

- Provided the right for university/ laboratory to own intellectual property
- Practically created the market for technology inventions and economic incentives.

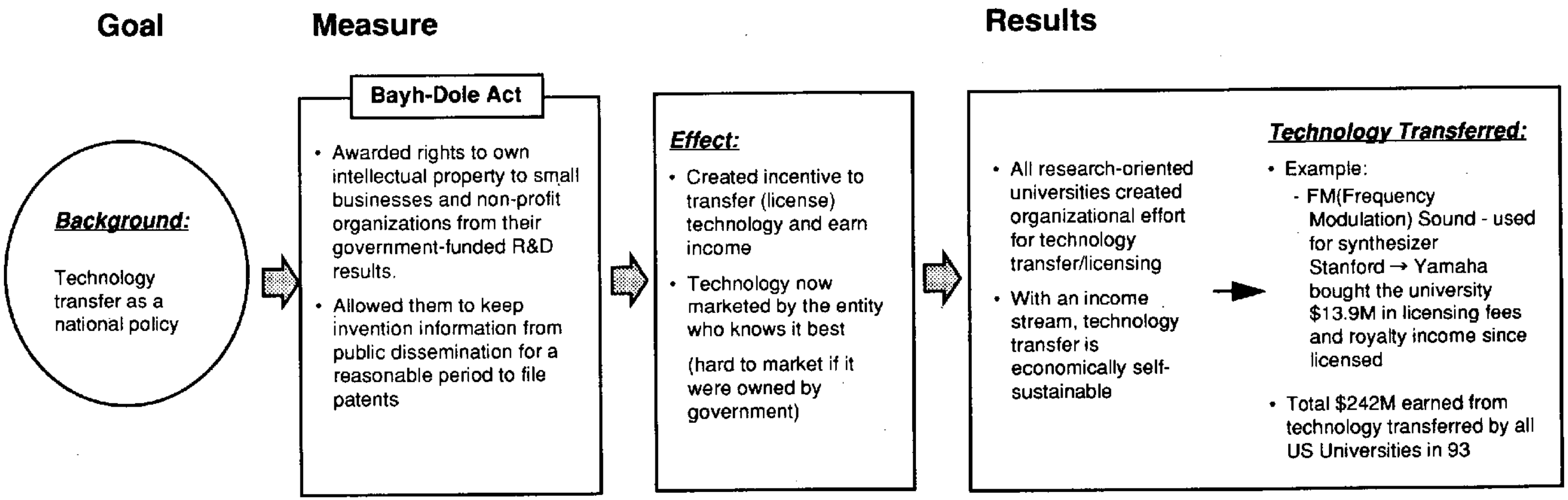
However, what makes the system work is the self-motivation of all parties under a free economy with minimal regulation.

*source; the Journal of Technology Transfer

Technology Transfer System - VII - Legal Infrastructure

The Bayh-Dole Act practically created the US market for technology. Subsequently, all universities jumped into the business of technology transfer and have been trying vigorously.

Bayh-Dole法は実質的に技術の市場を作り出したので、その後大学はこぞって技術移転のビジネスに乗り出し、その成功への大変大きな努力がなされてきている。



Goal

Background:

Technology transfer as a national policy

Measure

Bayh-Dole Act

- Awarded rights to own intellectual property to small businesses and non-profit organizations from their government-funded R&D results.
- Allowed them to keep invention information from public dissemination for a reasonable period to file patents

Effect:

- Created incentive to transfer (license) technology and earn income
- Technology now marketed by the entity who knows it best

  (hard to market if it were owned by government)

Results

- All research-oriented universities created organizational effort for technology transfer/licensing
- With an income stream, technology transfer is economically self-sustainable

Technology Transferred:

- Example:
  - FM(Frequency Modulation) Sound - used for synthesizer Stanford → Yamaha bought the university $13.9M in licensing fees and royalty income since licensed
- Total $242M earned from technology transferred by all US Universities in 93

2章のまとめ

以上米国の研究開発政策の方針と研究開発の仕組みを見てきて、以下のようなことが学べる。

- 政策のレベルで、研究開発成果・技術は、産業を通じた商業化・実用化をされてこそ、国民生活水準の向上・国の経済の向上に役立つものとの明確な認識がされ、その思想を仕組みの中に徹底している。
- 研究開発及び商業化を進めるために、自由市場での経済的インセンティブをもって、各自が自発的に行動する仕組みを選んでいる。これは規制により行動を管理しようとするのと正反対のアプローチであり、効率・効果ともに遥かに高いものが得られる。

日本的個人の
発想とは
違っているのでは
強く感じる

- Bayh-Dole法により知的所有権を大学・研究所に与えたことで、研究開発、技術移転、商業化に対する経済的インセンティブが作り出された。
- オープンな市場での競争原理により、各自がビジネス的緊張感の下に切磋琢磨する環境を作っている。

大事な言葉であろう。

- 産業も含めたオープンな研究開発プロジェクトの募集で、最高の研究開発能力、最先端の研究を確保している。
- 政府資金が世の中の役に立つため、商業化性を確保する方法として、産業の目を活用している。
- 研究成果の直接の商業化であるスピンオフにしても、それをサポートするサービスを自由市場で発生させることにより、ベンチャー・インフラストラクチャーと言える様な人材・資金の流動性が生まれ、スピンオフの成功、ひいてはIT産業の発展に大きく寄与した。

3 Technology Categories, Research Areas and Projects

ADL has tracked funding by broad technology categories, identified current “hot” research areas within each category, and drawn conclusions about characteristics and strengths of government-funded IT R&D in the U.S.

ADLでは、米国政府出資のIT研究開発の特徴と強みを見い出すために、技術の大分類とそれらへの出資について調査し、現在ホットな研究分野を特定、調査を行った。

やったことと、やれなかったことを明らかにしていない。

- funding can only be tracked by broad categories, a meaningful attempt to track funding by detailed research topic cannot be made

- current “hot” research areas are...

  - in computer systems : hive computing, mobile computing
  - in components : scalable parallel I/O, computational prototyping, molecular computing
  - in human interfaces and intelligent systems : multimodal interfaces, virtual and augmented reality
  - in information management : distributed,scalable multimedia databases, information retrieval
  - in communications : all-optical networking, high-confidence networking

ミツバチの巣箱、

- the U.S. system derives its success not from picking and funding the “right” topics but from maintaining an extremely diversified portfolio of areas and topics and by funding a sufficient number of comprehensive “ computer systems “ projects which facilitate feedback loops between research and development and between academia / labs and industry.

Note : URLs for all cited projects can be found in the Appendix

Technology Category and Funding - ADL Categorization

ADL has used a categorization which distinguishes infrastructure and application funding from computer and communications R&D funding.

ADLでは、インフラとアプリケーションへの出資を、コンピューターとコミュニケーションの研究開発出資と区別する分類を行った。

		%	Funding	Research Area	Trend (% of all funds)
Computer Systems Hardware & Software Technology and Architecture R&D	Hardware Technology and Architecture	5.0 %	$135 million	research advancing the state of computer hardware architecture and technology, such as research in scalable computer architectures, supercomputing, parallel processing, theoretical models of computation	⇨
	System software and middleware	14.0 %	$378 million	research advancing the state of computer software technology and creation of software tools and middleware, such as research in operating systems or programming languages and creation of libraries	⇘
Components R&D		18.4 %	$497 million	research in electronic components that might be applied to a variety of systems, such as research in optoelectronics, mass data storage, video processing, bus systems, electromechanical systems	⇨
Human Interface and Intelligent Systems R&D		8.8 %	$236 million	research in artificial intelligence, robotics, and human interface problems, such as research in speech recognition, natural language understanding, sensors, adaptive systems	⇨
Information management R&D		3.4 %	$92 million	research in information management systems, such as research in database design and management, query languages, transaction processing, logical and physical design	⇘
Communications R&D		7.1 %	$192 million	research advancing the state of computer communication technology, such as research in high - speed networking, wireless services, network security	⇗
	Subtotal	56.7%	$1,530 million		
Applications R&D	Computational Science Apps	14.8 %	$400 million	creation of software and computational techniques directed at solving specific scientific problems and applications, such as graphics and visualization techniques	⇗
	Non-scientific Applications	12.2 %	$329 million	creation of software for other than scientific purposes, and education and training, e.g. creation of military software, teacher or scientist education	⇨
	Subtotal	27.0%	$729 million		
Infrastructure	Computing	9.1%	$246 million	acquisition and operation of supercomputer facilities	⇘
	Communications	7.2%	$194 million	acquisition and operation of high - performance computer communications networks and services	⇗
	Subtotal	16.3%	$440 million		

(ADL Estimates for 1995)

Technology Categories and Funding - Two Existing Categorizations

The two existing official cross-agency approaches for tracking IT R&D funding by broad technology area differ in their categorization.

IT研究開発出資上の技術分野の分類としては省庁間をまたがった2つの分類があるが、それらは異なった分け方をしている。

HPCC Approach

- categorizes funding as part of one of five areas:
  - High-Performance Computing Systems
  - National Resource and Education Network
  - Advanced Software Technology and applications
  - Information Infrastructure Technology Applications
  - Basic Research and Human Resources

CIC* Approach

- categorizes funding as part of one of seven areas:
  - Components
  - Communications
  - Computing systems
  - Software Toolkits
  - Intelligent Systems
  - Information Management
  - Applications

* Committee of Information and Communications R&D - see page 1-33 et seq.

Technology Categories and Funding - HPCC Categorization

The HPCC categorization has several limitations that make it less useful as a base for tracking IT R&D by technology area.

HPCCの分類では、幾つかの欠点があり、IT研究開発の技術分野を分析するのには有用でない。

1995の話

こんなことをしたのか？

Program Component	Research Funded	FY96 Funding	%
High-Performance Computing Systems (HPCS)	scalable parallel systems, parallel i/o local-area workstation clusters, message-passing in massively parallel processors, systems tools for online analysis of real-time OS, shared memory	~ $155.77 million	13%
National Resource and Education Network (NREN)	network connectivity of public organizations, gigabit networking, advanced networking components, optical networking, network-capable applications and tools, network security, distributed file systems, privacy-enhanced communications, network management, ...	~ $186.05 million	16%
Advanced Software Technology & Applications (ASTA)	computational science applications for high-performance computers, parallel operating systems, languages and tools, parallel algorithm and data theory and application, distributed computing, ...	~ $390.41 million	33%
Information Infrastructure Technology Applications (IITA)	virtual reality, telepresence, network hypermedia, scaleable storage management and data repositories, object databases, multimedia objects, electronic copyright management, mobile computing, secure networks, private networks, ...	~ $326.91 million	28%
Basic Research and Human Resources (BRHR)	system software, programming languages, compilers, tools, virtual reality, algorithms and models, software engineering, computer and science education, ...	~ $106.71 million	9%

Source : HPCC FY96 Implementation Plan

Limitations:

- does not distinguish R&D from infrastructure funding
- does not distinguish IT applications R&D funding from pure IT R&D funding
- very coarse granularity, further breakdown difficult

Technology Categories and Funding - CIC Categorization

The CIC categorization is better in that it splits off applications but it still mixes infrastructure and research funding.

CICの分類は、応用分野を分けた点で優るが、それでもインフラと研究への出資を一緒に取り扱っている。

Technology Area	Technologies	Est. Spending	%
Components	processes for electronic components, optoelectronics, mass data storage, energy storage, electromechanical systems, models and processes for interconnect systems, electromechanical assembly, displays, lasers, video processing, high-bandwidth busses, ...	$370 million	18 %
Communications	analog and digital wireless services, micro to macro cellular systems, scaleable, reliable, and adaptive routing algorithms, multicasting, network security, network resource allocation and management, optical switching and transmission, satellite services, nomadic computing (campus-wide, rather than world-wide, mobile / portable computing) and access, internetworking and interoperability, encoding and compression, electronic commerce support, ...	$270 million	13 %
Computing Systems	balanced parallel systems, scalable parallel systems, multicomputers, local-area clusters of commodity workstations, parallel i/o, interprocessor communication, vector processing, shared memory abstractions, global management of memory and data, models of computation, theoretical foundations of computer design , ...	$290 million	14 %
Software Toolkits	language and programming paradigms, compiler methodology and optimization techniques, operating systems, human-computer interfaces, software tools and libraries, frameworks for application development, runtime systems, theoretical foundations of complex software systems, · · ·	$285 million	14 %
Intelligent Systems	speech recognition, native language understanding, knowledge-based systems, image processing and recognition, artificial intelligence, sensors, learning systems, adaptive systems, · · ·	$180 million	9 %
Information Management	database design and management, content analysis, dictionaries and indexes, data compression, data storage and organization, logical and physical design schemes, data description and manipulation language, query languages and processing, transaction processing, · · ·	$ 70 million	3 %
Applications	computational algorithms, computational geometry, computational and adaptive grids and data structures, symbolic and numerical computing, graphics and visualization techniques, mathematical models of physical and biological systems for parallel processing ; all in the context of HPCC's Grand and National Challenges	$550 million	27 %

Source : CIC

Limitations:

- does not distinguish R&D from infrastructure funding
- no historical data available
- very coarse granularity, further breakdown difficult

Technology Categories and Funding - NSF

Breaking down funding beyond such broad categories in any meaningful way would be possible only by examining each of thousands of individual grants in detail: Among the two major funding agencies, NSF's most detailed breakdown is still too coarse and it reflects NSF's rather static organizational structure more than the actual topics funded...

それら以上に出資領域を意味のある形で細分化する必要はあるが、それを正しく行うためには無数の個々の出資案件を調べなくてはならず不可能である。NSFでの最も細かい分類を取ってみてもまだ粗く、しかもそれは研究領域というよりNSFのやや固定的な組織構造をより反映したものになっている。

CISE (Computer and Information Systems Engineering) Directorate - All Programs	FY95 ($ million)	Research Topics Covered*
Computer & Computation Research	**40.3**	• fundamental theory underlying development of better applications
Computer & Computation Theory	9.8	• numerical solutions of science and engineering applications
Numeric and Symbolic Computation	7.5	• problems in creating, maintaining, and managing real-time systems
Computer Systems Architecture	4.4	• programming language for high-performance computing
Software Systems	13.4	• computer security
Software Engineering	5.3	• computational geometry
Information Robotics & Intelligent Systems	**32.3**	• design of database and knowledge-based systems
Knowledge & Database Systems	14	• information systems in distributed and networked environments
Robotics and Machine Intelligence	7.1	• virtual reality and multimedia
Interactive Systems	5.6	• human language technology
Information Technology and Organizations	5.6	• sensor-based control of intelligent robots
Microelectronics Information Processing Systems	**25.8**	• theoretical foundation of IC and system design
Design, Tools and Test	4.8	• rapid systems prototyping for experimentation and manufacturing
Microelectronics System Architecture	4.5	• package and interconnect technologies
Circuits and Signal Processing	4.8	• computing systems architectures and design methods
Experimental Systems	8.3	• multi-dimensional and VLSI signal processing
Systems Prototyping and Fabrication	3.4	
Advanced Science Computing	**79.2**	• software tools for high performance computing
Centers	73.5	• computational techniques and software for parallel systems
New Technologies	5.8	• computer graphics and science visualization
Networking and Communications Research Infrastructure	**56.5**	• communications, information, and network theory and technology
NSFNet	45.2	• coding and coded modulation • radio systems and networks
Networking and Communications Research	11.2	• video, speech, image, and data compression • protocol theory
Cross-Disciplinary Activities	**24.2**	• instructional software and technologies
CISE Institutional Infrastructure	20.7	• computer education
CISE Instrumentation	3.6	
Engineering (Electrical & Comm. Systems Program Only)	**38.5**	
Quantum Electronics, Waves, and Beams	10.0	• optoelectronics and optical computing and storage
Communications and Computational Systems	7.4	• optical networking technology
Solid State and Microstructures	11.6	• microwave communications
Engineering Systems	9.4	• computational engineering
		• microelectronic mechanical devices, materials, and processes
		• semiconductor processing and manufacturing
		• neural networks, neural engineering

* This list is illustrative. Inclusion / ommision is not indicative of importance

Source : NSF, FY95 Budget Estimate

Technology Categories and Funding - DARPA's Current Program Areas

...while DARPA's approach of programs as temporary projects gives better insights in the actual areas being funded but the amount of funding allocated to each area is not publicly available.

DARPAにおけるプログラム領域の分類は、実際の出資領域に関して、より理解を助けるが、各領域毎の出資額については公表されていない。

Information Technology Office Program Areas

Computing Systems & Software Area:
- Microsystems
  - Design Technology
  - Computational Prototyping
  - Microarchitectures
- Scalable Systems & Software
  - Prototype Scalable Systems
  - Operating Systems and Services
- Embeddable Systems
- Systems Environments
  - Languages and Runtime Services
  - Scalable Software Library Technology
  - Experimental Applications
- Artificial Neural Network Technology (ANNT)

Intelligent Systems & Software Area :
- Evolutionary Design of Complex Software (EDCS)
- Software Engineering Institute (SEI)
- Information Survivability
  - High Confidence Networking
  - High Confidence Computing Systems
  - Assurance and Integration
  - Survivability and Vulnerability
- Computer Aided Education and Training (CAETI)
  - Expert Associates to Guide Individualized Learning (EAGIL)
  - Collaborative Applications for Project-based Educational Resources (CAPER)
  - Smart Navigators to Access and Integrated Resources (SNAIR)
- Software Technology for Adaptable Reliable Systems (STARS)

Networked Systems Area:
- Networking Systems (NETS)
  - Internetworking
  - High Performance Networking
  - Advanced Developmental Networking
- Broadband Information Technology (BIT)
  - Multiwavelength Optical Networking Consortium (MONET)
  - National Transparent Optical Network Consortium (NTONC)
  - WDM with ElectronicSwitching Technology (WEST)
  - IBM/Corning Optical Network (ICON)
  - Innovative device technology and solution-based Time Division Multiplexing (TDM)
- Defense Technology Integration and Infrastructure (DTII)
  - Application Support Technology (GloMo)
  - Technology and Services Validation (TSV)
- Global Mobile Infosysytems (GloMo)
  - Modular multifunction Wireless Nodes
  - Wireless Node Design Technology
  - Multi-hop Network Technology
  - Mobie Internetwork Technology
  - Mobie Application Support
- Human Computer Interaction (HCI)
- Human Language Systems (HLS)

Electronics Technology Office Program Areas

- Advanced Lithography Program (ALP)
- Analog/Digital Converter Demonstration
- Display Technologies
  - High Definition Systems (HDS)
  - Head Mounted Displays (HMD)
- Electronic Packaging and Interconnect (EP&I)
  - Physical Electronic Packaging (PEP)
  - Application Specific Electronic Modules (ASEM)
  - Multi-Chip Integration (MCI)
  - High Density Microwave Packaging (HDMP)
- High Power Electronics
- Infrared Focal Plane Array (IRFPA)
- Integrated Imaging Sensors
- Low Power Electronics (LPE)
- Microelectromechanical Systems (MEMS)
- Microwave Technologies
  - Microwave and Millimeter Wave Monolithic Integrated Circuits (MIMIC)
  - High Density Microwave Packaging (HDMP)
  - Microwave Analog Front-End Technology (MAFET)
- Optoelectronics
- Rapid Prototyping of Application Specific Signal Processors (RASSP)
- SEMATECH
- Tactical Information Assistants (TIA)
- Ultra Dense Ultra Fast Computing Components (ULTRA)

We have therefore focused on identifying 'hot' research areas in each category, mainly through interviews - research areas which are believed to have either good prospects for significant near-term commercial impact or have a potentially high long-term impact but uncertain chances for success.

本調査では従って、各分類中のホットな分野を、主にインタビューを通じて特定することに注力した。短期的に相当の商業化のインパクトがありそうか、あるいは長期的に見て大きな影響を与える可能性のあるものを選んだ。

hot-research areaはどれと特定するのは. Interviewしかなかったということ

これを調べられたことあり.

Category	High-Leverage 'Hottest' Research Areas	Key Projects and Places*
Computer Systems Hardware and Software Technology and Architecture	• hive computing • mobile computing	• NOW (Berkeley), FLASH (Stanford) • Infopad (Berkeley), Dataman (Rutgers)
Components	• scalable parallel I/O • computational semiconductor prototyping • molecular computing	• HPSS (Lawrence Livermore), SIO (Caltech) • CP21SS (Stanford) • USC, Princeton, Xerox PARC
Intelligent Systems and Human Interface	• multimodal user interfaces • augmented reality	• Human Language Interface Projects(CMU) • Vu Man (CMU),Virtual Retina Display (Washington)
Information Management	• distributed, scaleable multimedia databases • information retrieval	• Digital Library (Berkeley) • Image Querying (Washington)
Communications	• all-optical networking • high-confidence networking	• Optical Networks (Princeton) • NetBill (CMU), Secure Internet Routing (BBN)

Interviewによる
ADLが選んだ

HOT-AREA
↓
(110-119)
すべてを見るか...

* Please note : this list is illustrative. Omission / inclusion should not be taken as indicative of importance

3 **Technology Categories, Research Areas and Projects**

3.1 **Technology Categories and Funding**

3.2 **Research Areas and Projects**

- Computer Systems
- Information Management
- Components
- Communications
- Intelligent Systems, HCI

3.3 **Conclusion and Lessons**

Computer systems hardware and software technology R&D continues to be dominated by the themes of parallel and distributed computing.

コンピューターシステムのハードウェアとソフトウェア技術の研究開発は、引き続きパラレル(並列)・コンピューティングと分散コンピューティングである。

Category and Definition	Technologies Regarded as Critical ...	... for national security	... for national competitiveness	Areas Recommended for Government R&D Funding by the CIC	Related DARPA ITO Programs	"Hot" Research Areas Interview Mentions, Unedited
Computer systems hardware and software technology and architecture research advancing the state of computer hardware architecture and technology, such as research in scalable computer architectures, supercomputing, parallel processing, theoretical models of computation; and research advancing the state of computer software technology and the creation of software tools and middleware, such as research in programming languages and the creation of libraries	**parallel computing :**			**parallel computing :** • scalable parallel systems and multiprocessors • workstation clusters • distributed processing systems **fault-tolerant highly available systems real-time response, highly portable systems hardware and systems design:** • reliability analysis • graph theory • system timing methodologies **operating systems and runtime systems support :** • interoperability and scalability • distributed and heterogeneous systems • distributed access and control in virtual environments • real-time communication exchange **software tools and development environments:** • improved productivity • reusable components • support models for debugging • performance analysis • performance tuning **languages and compilers:** • support for distributed memory systems • automatic detection of parallelism • support for parallel i/o • compiler optimization techniques • support for object-oriented paradigms • support for multi-modal user interfaces • portable and collaborative work tools **high-confidence systems :** • formal verification and authorization • tools for automating program correctness • security tools and frameworks	**scalable systems & software:** • prototype scalable systems • operating systems and services **embeddable systems** **systems environments** • languages and runtime services • scalable software library technology • experimental applications information survivability • high confidence computing systems **global mobile infosystems** • modular multifunction wireless nodes • wireless node design technology (see also under communications) **software technology** • evolutionary design of complex software • software engineering institute • software technology for adaptable, reliable systems	• workstation clusters / hive computing • parallel computing • security in distributed computing • robustness improvements in distributed contexts • distributed, communicating objects • mobile code (small code objects travelling over a network) • portable code (code that can be reused on a variety of platforms) • modular applications • Java "spin-ons" • software productivity
	• multiple-instruction, multiple-data-stream (MIMD)	●	●			
	• single-instruction, multiple-data-stream (SIMD)	●	●			
	• very-large-instruction-word (VLIW)	●	●			
	• systolic-arrays	●	●			
	• specialized parallel coprocessors	●	●			
	• hypercubes	●	●			
	interoperability :	●	●			
	• data interchange standards	●	●			
	• product data exchange	●	●			
	systems software :					
	• transparent embedding software	●	●			
	• operating systems	●	●			
	• runtime execution systems	●	●			
	• programming languages	●	●			
	• interpreters	●	●			
	• compilers	●	●			
	software engineering tools:					
	• CASE tools	●	●			
	• user interface design tools	●	●			
	• software testing tools	●	●			
	• IC design tools	●	●			
	software production :					
	• rapid prototyping	●	●			
	• modular / object-oriented programming	●	●			
	multimedia tools	●	●			

source : National Critical Technologies Panel

source : CIC

source : DARPA

source : ADL interviews

The two 'hottest' research areas in systems at the moment are Hive Computing and Mobile Computing.
コンピューターシステムの大分野で現在ホットな分野は群コンピューティング(Hive Computing)とモービル・コンピューティングである。

Hive Computing :

- has replaced massively parallel processors as the favored approach for parallel computing
- builds on previous research in parallel computing but also introduces many new issues, e.g.

- distributed shared memory	- gang- scheduling of parallel programs
- active messages passing	- dynamic load balancing through process migration

Mobile Computing :

- the software and communication aspects in particular are subject of intense research, e.g.

- protocol support for roaming hosts- location - dependent browsing

- graceful degradation in environments-exactly - once delivery of multicast messages with heterogeneous bandwidth to mobile hosts

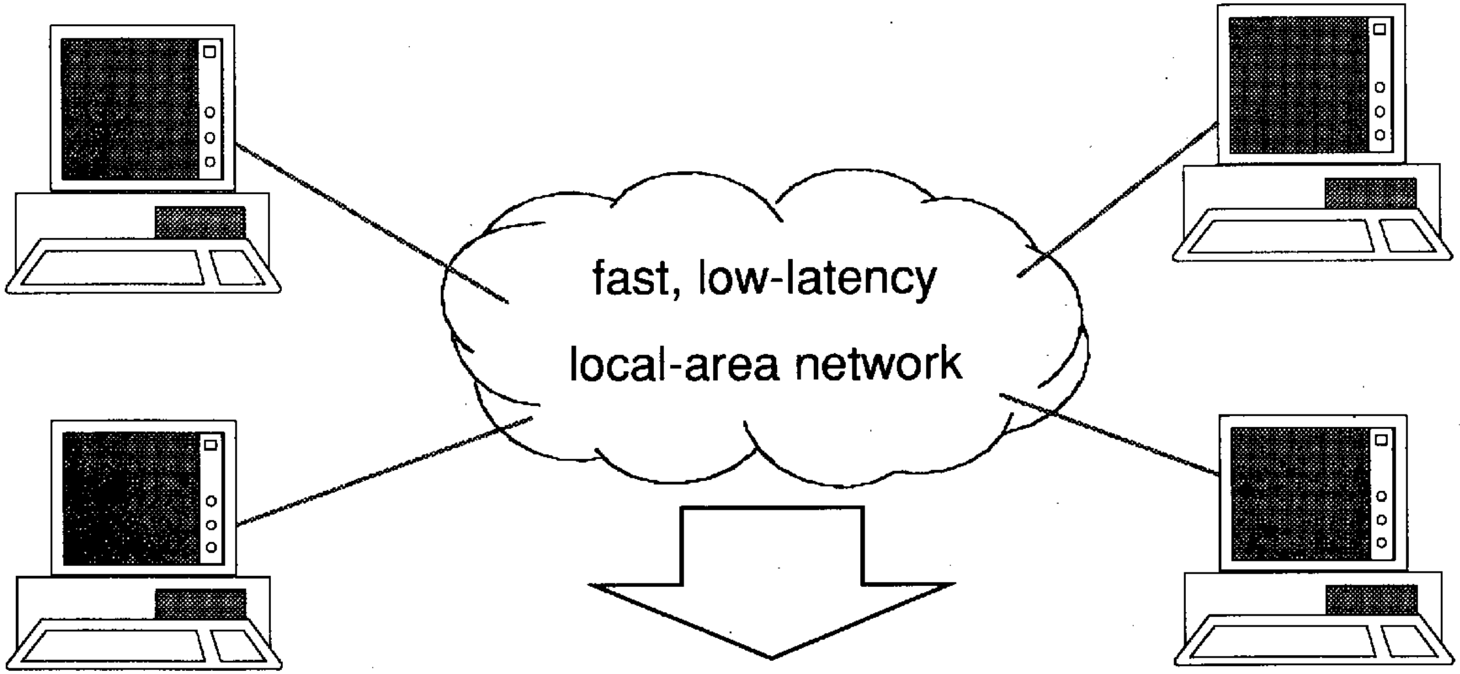
Other Areas :

- while the area of object- oriented code (essentially 'modular' code) has been active for quite some time, several interviewees stressed that area will likely see a revival as the Internet enables a 'software-on-demand' model where clients can download software 'objects' as required (e.g. Bob Taylor, Gordon Bell)*
- related to this, software development productivity was still regarded as a big problem but interviewees had little opinion on how exactly this issue might be solved (e.g. Ed Lazowska, Gordon Bell)

* see Appendix for full list of interviewees / occupations

The concept of hive computing is about networked desktop computers working together to share memory, processing, and mass storage throughout the network, effectively placing the combined resources of the total network at the command of each individual machine.

群コンピューティングの概念は、ネットワーク化された複数のデスクトップコンピューターが協調処理をすることである。コンピューター群がCPUプロセス、メモリー、記憶装置等をネットワークを介して共用し、1つのコマンドに対して全ての資源を使って効率的に処理を行う。



fast, low-latency

local-area network

- local memory
- local processor(s)
- local hard disk

appears to each connected machine as one large...

...memory space

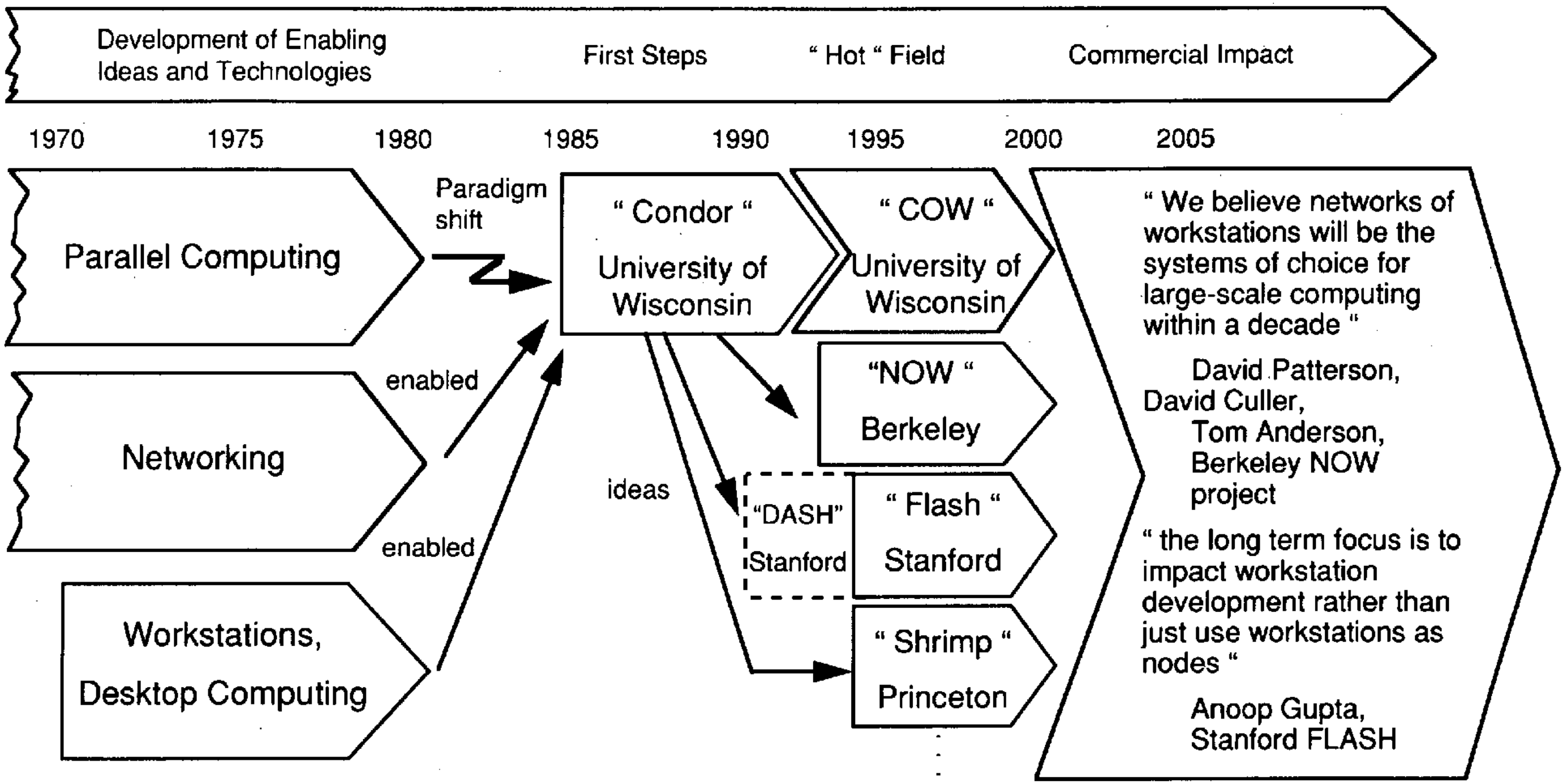
...multiprocessor system

...RAID

SIMPLIFIED

Hive computing is forecast to have mainstream commercial impact in 5 to 10 years. In fact, the topic has had a history of about 10 years already...

群コンピューティングは5〜10年で商業化され大きなインパクトを与えると見られている。この分野の研究は既に10年の歴史を持つ。



" We believe networks of workstations will be the systems of choice for large-scale computing within a decade "

David Patterson, David Culler, Tom Anderson, Berkeley NOW project

" the long term focus is to impact workstation development rather than just use workstations as nodes "

Anoop Gupta, Stanford FLASH

...but it has been only recently that its enabling technologies have crossed certain performance thresholds and elevated it into a hot, high-impact research topic in systems architecture.

しかし、この概念を成立させる必要技術が一定以上の性能・経済性を持って揃ってきたのは最近のことで、そういった背景の充実によりこの分野は今ホットとなっている。

	Technology	Economics
Processors	power of workstations closing in on that of large systems...	...while market scale leads to bigger economies of scale and quicker time to market
I / O	while processors are getting faster, disks are only getting bigger...	...which increases the incentive to avoid disk I/O by all means and leads to ever bigger memory configurations
Network	gigabit switched local area networks are arriving...	...and are offering a way to leverage existing resources on other desktops on the network more easily

Hive Computing - Benefits

These developments place hive computing in an increasingly favorable competitive position versus massively parallel machines and research attention has shifted accordingly.

それらの開発により群コンピューティングは巨大パラレルマシンとの競争上益々有利になってきて、研究の注力もそれに合わせて移行してきた。

...for parallel applications

- through faster processing :

Machine (no.processors)	ODE*	Transport (second)	I/O	Total
Cray C-90 (16)	7	4	25	36
Intel Paragon (256)	12	24	10	46
RS/6000 (256), Ethernet	4	23,340	4,030	27,374
+ ATM	4	192	2,015	2,211
+ Parallel file system	4	192	10	206
+ low net. overhead	4	11	10	25

(1 disk/processor, parallel FS for C-90, Paragon)

- Order of importance : ATM bandwidth, Parallel File System, low overhead ATM/SW=>1000X

* Time required for execution of test code

...for sequential applications

- through faster memory and disk access :

	Latency (μ sec)	BW (MB/s)	Size (MB)	Cost	Cost/MB ($/MB)
Cache	0.032	500	0.25	$500	$2,000
DRAM	0.32	50	64	$2,500	$40
Network RAM	20*	15	6400	$2,000	$0.30
Disk	10,000	2	1000	$1,000	$1.00
NetworkDisk	10,250*	15	100000	$2,000	$0.02

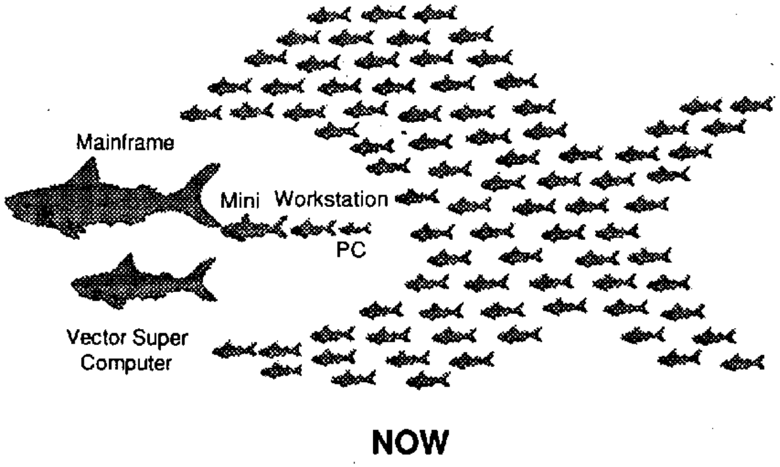
(*provided have low overhead network interface that avoids OS)

Source : NOW project

The Network of Workstations (NOW) project at Berkeley is the largest, most visible project in the area of hive computing.

群コンピューティングの分野では、UC BerkeleyのNOW(Network of Workstations)プロジェクトが最大規模で注目も集めている。

The Berkeley NOW Project



The Berkeley NOW project is building system support for using a network of workstations (NOW) to act as a distributed supercomputer on a building-wide scale.

In conjunction with complementary research efforts in operating systems and communication architecture, we hope to demonstrate a practical 100 processor system in the next few years that delivers at the same time

(1) better cost-performance for parallel applications than a massively parallel processing architecture (MPP) and

(2) better performance for sequential applications than an individual workstation.

This goal requires combining elements of workstation and MPP technology into a single system. If this project is successful, has the potential to redefine the high-end of the computing industry. To realize this project, we are conducting research and development into network interface hardware, fast communication protocols, distributed file systems, and distributed scheduling and job control.

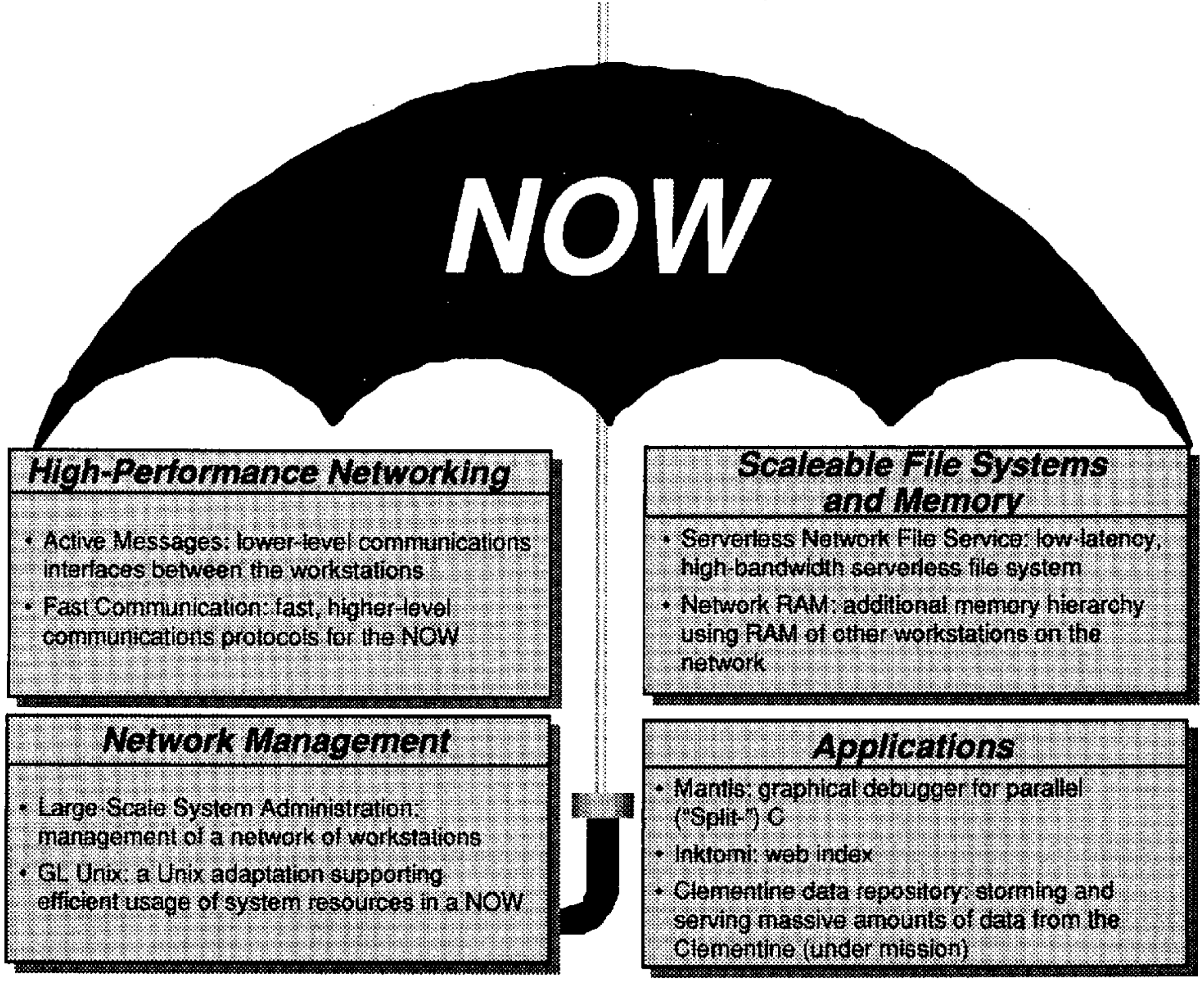
Industry 側は、誰が

参加しているんか???

Hive Computing - NOW Project - Reseach Area

Various topics related to the overall idea of Hive Computing are researched under the umbrella of the NOW project.

群コンピューティングという全体を構成する色々な領域の研究がNOWプロジェクトの傘下で行われている。



High-Performance Networking

- Active Messages: lower-level communications interfaces between the workstations
- Fast Communication: fast, higher-level communications protocols for the NOW

Scaleable File Systems and Memory

- Serverless Network File Service: low-latency, high-bandwidth serverless file system
- Network RAM: additional memory hierarchy using RAM of other workstations on the network

Network Management

- Large Scale System Administration: management of a network of workstations
- GL Unix: a Unix adaptation supporting efficient usage of system resources in a NOW

Applications

- Mantis: graphical debugger for parallel ("Split-") C
- Inktomi: web index
- Clementine data repository: storming and serving massive amounts of data from the Clementine (under mission)

The NOW team is led by David Patterson, who has been strongly involved in the R&D for RISC and RAID.
NOWプロジェクトチームはDavid Patterson教授により指揮されている。彼はRISCプロセッサーとRAIDの研究開発に深く関わった経験を持つ。

David Patterson

- Professor
- PhD from UCLA
- led design and implementation of first VLSI RISC, which became the basis of Sun's SPARC architecture
- developed the idea of RAID together with Randy Katz

David Culler

- Associate professor
- PhD from MIT
- long research record in parallel and distributed computing, particularly languages and compilers

Thomas Anderson

- Assistant Professor
- PhD from University of Washington
- research focus on operating systems in parallel computing

Technical Staff

- Eric Fraser
- Ken Lutz

Graduate and PhD students

- Remzi Arpaci
- Satoshi Asami
- Mike Dahlin
- Andrea Dusseau
- Dougas Ghormley
- Seth Goldstein
- Kim Keeton
- Cedric Krumbein
- Lok Tin Kiu
- Steve Lumetta
- Alan Mainwaring
- Rich Martin
- Jeanna Neefe
- Steve Rodrigues
- Drew Roselli
- Amin Vahdat
- Keith Vetter
- Randy Wang
- Chad Yoshikawa

NOW receives funding from various federal agencies, from the state government , and from a wide range of industrial sponsors.

NOWプロジェクトは色々な政府省庁、州政府、そして産業界から出資を受けている。

Grants

* DARPA Grant N00600-C-2481. Roboline Storage: Low Latency High Capacity Storage Systems.

* Lawrence Livermore National Laboratories Grant LLL-B28 3537. Active Messages and Split-C.

* California MICRO Grant. Research in High Performance File Systems for Global Change Research.

* California MICRO Grant. Near-Line Storage Systems Based on Striped Helical Scan Tape Systems.

* National Science Foundation Grant CCR-9257974. NYI-Operating System Support for High Performance Applications and Architectures. < $275,000 over 5 years >

* National Science Foundation Grant PFF-CCR-9253705. Pff-Highly Parallel Architectures. < $300,000 over 3 years >

Corporate Sponsors

* The AT&T Foundation

* Digital Equipment Corporation

* Exabyte Corporation

* Hewlett-Packard Company

* Intel Corporation

* International Business Machines

* Siemens Corporation

* Sun Microsystems

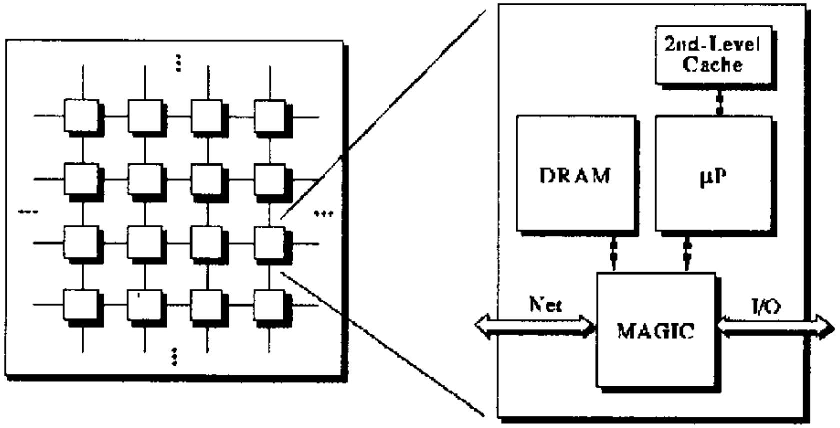
* Synoptics Corporation

* Xerox Corporation

Hive Computing - FLASH Project - Overview

The FLASH (Flexible Architecture for Shared memory) project at Stanford University aims at merging the two main concepts in the area of hive computing: message passing and shared memory

Stanford大学のFLASH(FLexible Architecture for SHared memory)プロジェクトでは、メッセージ伝達と共有メモリーという群コンピューティングの2つの主要概念を統合する研究が行われている。



FLASH is a convergence architecture multiprocessor able to support a variety of communication models, including shared memory and message passing protocols. It relies on MAGIC, a programmable node controller. FLASH achieves both low hardware and low software overhead.

The goal is to develop a scalable multiprocessor and a test platform which:

-- can support multiple communication protocols and different workstation environments

-- can be used either as a traditional "standalone" supercomputer, a computer server, a robust multiuser system, or a distributed system

The flexibility of the FLASH design makes it suitable for a wide variety of applications and networks of workstations.

Hive Computing - FLASH Project - Research Area

The FLASH project covers the complete range of key points in the area of hive computing. The goal is to reach a complete system with its hardware, its architecture and its large-scale applications

FLASHプロジェクトでは群コンピューティングの重要な点を全て範囲に含んでいる。その目標はハードウェア、アーキテクチャー、大規模アプリケーションを含む完全なシステムに到達することである。

Architecture	FLASH: scalable multiprocessor able to support a variety of communication models, including shared memory and message passing protocols. MAGIC (Memory And General Interconnect Controller): custom chip centered around the Protocol Processor which performs the two fundamental tasks: data movement and knowledge state manipulation.
Operating Systems	HIVE OS is structured as an internal distributed system of independent kernels called cells. This improves reliability because a hardware or software fault damages only one cell rather than the whole system, and scalability because few kernel resources are shared by processes running on different cells.
Simulation technology	SimOS is a complete machine simulation environment designed for the efficient and accurate study of both uniprocessor and multiprocessor computer systems.
Compilers and Languages	SUIF is a flexible framework for the research of compiler techniques. The goal is to manage the data and the computation in order to minimize communication.
Parallel Applications	Ocean Simulation, Hierarchical Radiosity, Ray Tracer, Volume Renderer, Water Simulation with/ without Spatial Data Structure

Hive Computing - FLASH Project - Research Team

The FLASH team is led by John L. Hennessy who has been strongly involved in the invention of VLSI RISC.
FLASHプロジェクトチームはJohn L. Hennessy教授により指揮されている。彼はVLSI RISCの発明に深く関わった経験を持つ。

John L. Hennessy

Professor of Electrical Engineering
and Computer Science,
Chairman, Computer Science Dept,
Stanford

-- initiated the MIPS project at Stanford in 1981: high-performance RISC Reduced Instruction Set Computer, built in VLSI

-- led the DASH (Distributed Architecture for Shared Memory) multiprocessor project, the predecessor of FLASH

-- key role in transferring this technology to industry: cofounded MIPS Computer Systems, now part of Silicon Graphics,

Anoop Gupta

Associate Professor
Computer Science Dept. Stanford

Faculty and Ph.D or Carnegie Mellon University, has received outstanding awards for his work

Co-led DASH with J. Hennessy
Involoved in FLASH and the Virtual Classroom Project

6	Faculty
2	Research assistant
2	Staff
43	Graduate students

Architecture

4 Faculty	Professor, Associate Professors Assistant Professor
2 Research Associates	
17 graduate	

Simulation

1 Faculty	Assistant Professor
3 Graduate	

Operating systems

2 Faculty	Associate Professor, Assistant Professor
8 Graduate	

Compilers

1 Faculty	Assistant Professor
16 Graduate	

Applications

2 Faculty	Professor, Associate Professor
4 Graduate	

The FLASH machine is being developed in partnership with the Information Technology Office in DARPA, and with significant cooperation from corporate sponsors. This project is part of the High Performance Computing and Communications Program.

FLASHマシンは、DARPAのInformation Technology Officeと多くの産業界の協力により開発されている。このプロジェクトはHPCCプログラムの一環にもなっている。

Grants

DARPA contract N00039-91-C-0138

DARPA contract DABT63-94-C-0054, DABT63-91-K-0003

DARPA and Air Force Material contract F30602-95-C-0098

National Science Foundation Career Award

National Science Foundation Presidential Young Investigator Award

National Science Foundation Fellowships

Air Force Laboratory Graduate Fellowship

Fannie and John Hertz Foundation Fellowship

Powell Foundation

Corporate Sponsors

AT&T Bell Laboratories

Digital Equipment Corporation's Western Research Laboratory

Hewlett-Packard

Intel Corporation, Supercomputer Systems Division

LSI Logic

MIPS Technologies

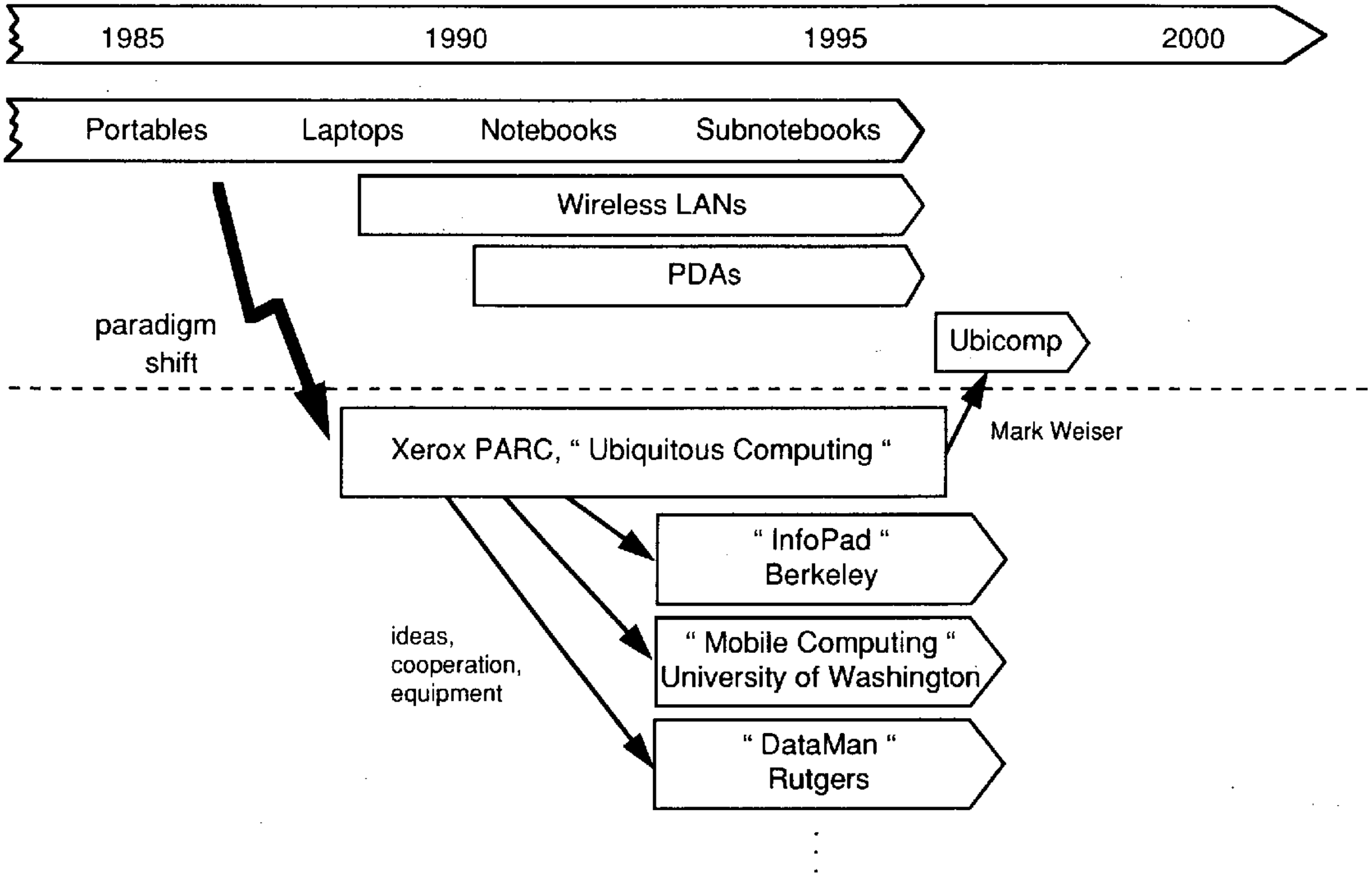
Cooperation with Jet Propulsion Laboratory

Other places and people are also working on hive computing projects.
群コンピューティングの研究は他の各地でも行われている。

- Princeton, " SHRIMP ", Kai Li, grants from DARPA, NSF, industry
- Wisconsin, " Condor " and " Cow ", Miron Livny, grants from NSF, DEC
- Illinois, " I-ACOMA ", Josep Torrellas, grants from NSF
- MIT, " Alewife ", Anant Agarwal, grants from DARPA, NSF, others
- Cornell, " HORUS ", Kenneth Birman, grants from DARPA, office of Naval Research, industry
- Rice, " TreadMarks ", Willy Zwaenepol , grant from Texas ATP
- Utah, " Avalanche ", AL Davis, grants from DARPA, Navy
- Toronto, Ca., " NUMAchine "
- Bristol, UK, " Data Diffusion Machine "
- Swedish Institute of Computer Sciences, Sweden, " Simple COMA "
- Universitat des Saarlandes, Germany, " SB - PRAM "

The field of mobile computing with the focus of continuous network connectivity of a comparatively dumb terminal evolved from research done at Xerox PARC in the 80's and currently receives considerable attention and funding

モービル・コンピューティングの分野では、比較的単純な種々の端末を途切れることなくネットワーク接続する考え方に基づく研究が現在注目と出資を集めている。この領域は80年代にXerox PARC研究所から生まれてきた。



1985 1990 1995 2000

Commercial Development

Portables Laptops Notebooks Subnotebooks

Wireless LANs

PDAs

Ubicomp

paradigm shift

Mark Weiser

Xerox PARC, " Ubiquitous Computing "

Industry Labs & Universities

ideas, cooperation, equipment

" InfoPad " Berkeley

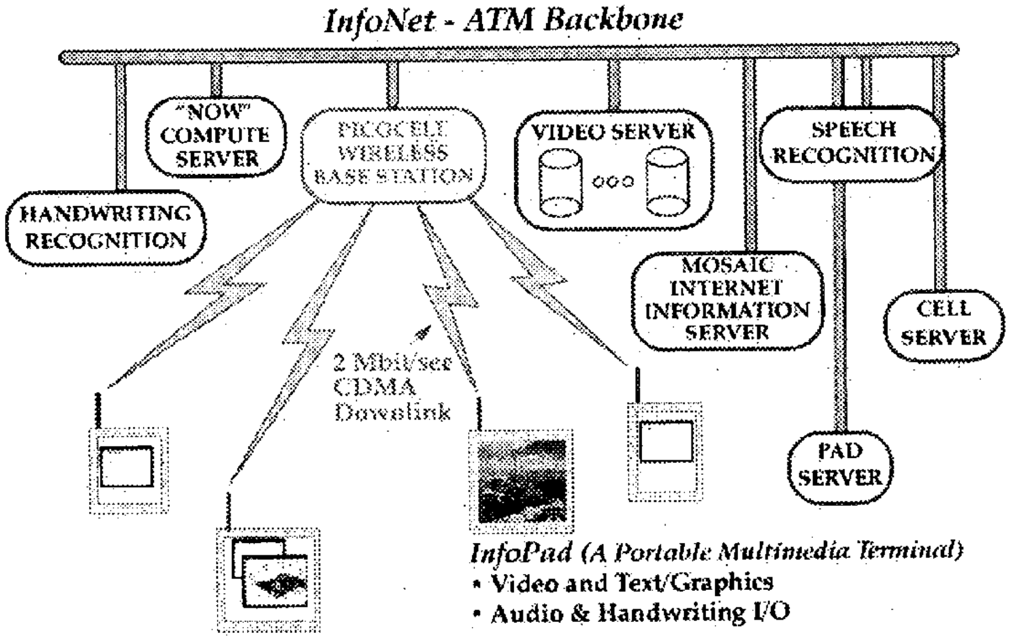
" Mobile Computing " University of Washington

" DataMan " Rutgers

Mobile Computing - InfoPad Project - Overview

The goal of Berkeley's InfoPad project is the implementation of a complete prototype wireless computing environment.

UC BerkeleyのInfoPadプロジェクトは、ワイヤレス・コンピューティング環境全体の完結したプロトタイプを作ることを目標としている。



InfoPad (A Portable Multimedia Terminal)
- Video and Text/Graphics
- Audio & Handwriting I/O

- implement a wireless computing environment which will allow 50 users in a confined area to simultaneously access and communicate with multimedia network services using a low-cost, light-weight tablet

- covers all aspects of the environment, from the terminal and basestation hardware and software to the wireless protocols to the middleware and applications

Because of InfoPad's comprehensive scope each of its six subprojects is a sizable project of itself.

InfoPadプロジェクト全体としてはその対象範囲があまりに広いために、6つの子プロジェクトそれぞれが相当な規模のプロジェクトとなっている。

Pad Group

- design of InfoPad terminal hardware and basestation
- led by Bob Brodersen, Jan Rabaey
- 10 students

Info Net Group

- network support for mobility, such as connections, quality of service, frequency & power allocation
- led by Jan Rabaey, Randy Katz, Eric Brewer
- 12 students

Medley Group

- backbone network servers and protocols for video and graphics transport
- led by David Messerschmidt
- 8 students

User Interface Group

- User interface, middleware, and applications ; e.g. speech & handwriting recognition, Web browser
- led by Eric Brewer, Bob Brodersen, Randy Katz
- 7 students

Wireless Communications Group

- adapt existing wireless LAN technology for InfoPad and develop own highspeed RF downlink transceiver for future InfoPad versions
- led by Bob Brodersen
- 10 students

InfoDesign Group

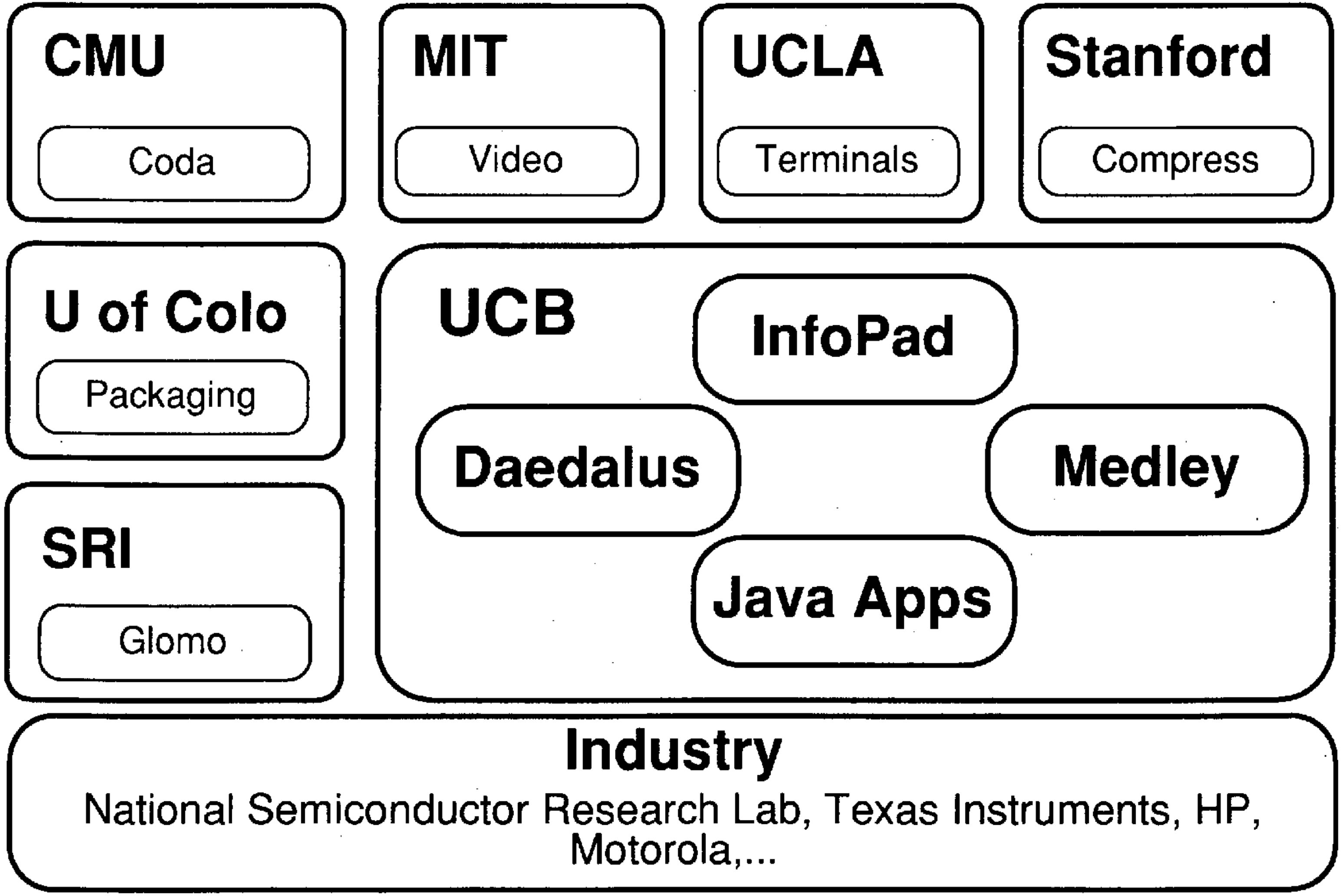
- systems and low-power design support
- led by Jan Rabaey, Paul Wright
- 16 students

these two groups also work on projects outside InfoPad

Mobile Computing - InfoPad Project - Cross - University and Industry Cooperation

The InfoPad project is also a catalyst for cooperation beyond Berkeley with other universities and with industry labs.

InfoPadプロジェクトはUC Berkeley学内を越え、他の大学や産業の研究所との協力関係を生み出している。



CMU

Coda

MIT

Video

UCLA

Terminals

Stanford

Compress

U of Colo

Packaging

SRI

Glomo

UCB

InfoPad

Daedalus

Medley

Java Apps

Industry

National Semiconductor Research Lab, Texas Instruments, HP, Motorola,...

InfoPad receives its government funding from DARPA's Global Mobile Infosystems (GloMo) program.

政府からの出資としては、DARPAのGlobal Mobile Infosystems(GloMo)プログラムからInfoPadに資金が出ている。

Grants

DARPA GloMo program grant

Corporate Sponsors

Intel

IBM

Ericson

Motorola

HP

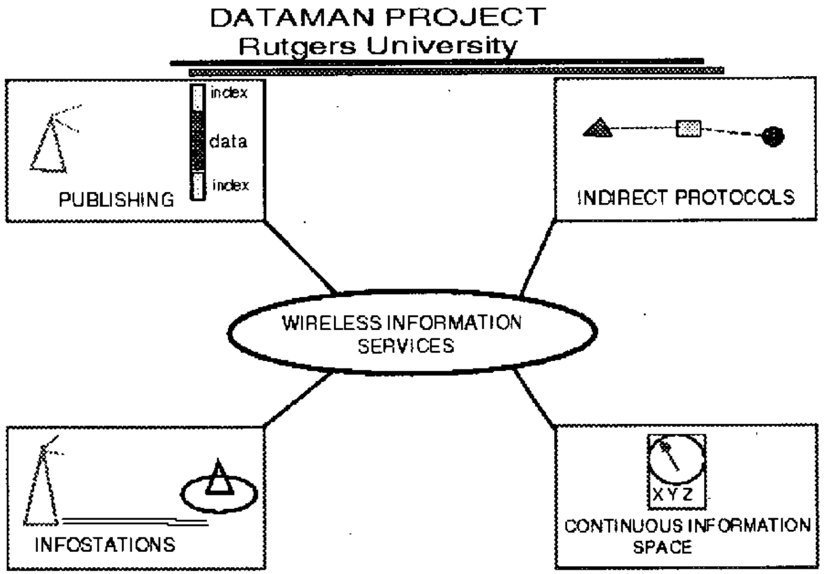
National Semiconductor

Texas Instruments

The Dataman group at Rutgers University investigates protocols, services, and other issues involved in being wirelessly “on - line”.

Rutgers大学のDatamanプロジェクトでは、ワイヤレスでの「オンライン」接続に関してのプロトコルやサービス他の課題について研究している。

Dataman : “ Low Power Adaptive Wireless Information Services “



A mobile computing environment is simulated, with base stations and mobile hosts. A Mobile IP protocol is used to provide a virtual mobile subnet made of multiple wireless cells across which the mobile hosts can move without having to change their address. The following key points have been developed :

- Infostations : base stations, information kiosks
- Publishing information : various kinds of data can be exchanged
- Communication protocols : information exchange tools
- Continuous information space : mobility of the users

Mobile computing tools have been developed to tackle the main technical issues. Based on these tools, large applications can be designed to benefit from the mobile computing possibilities and the information availability.

Mobile Computing - Dataman Project - Research Area, Applications

As opposed to InfoPad, which is focused on the development of a prototype building-scale mobile computing environment, Dataman explores a multitude of issues arising from wirelessly connected mobile computers.

InfoPadがプロトタイプ規模でのモービル・コンピューティング環境を作ることを目標としているのに対し、Datamanではワイヤレスに接続されたコンピューターに関するあらゆる課題についての究明を目指している。

Theoretical research and Tool Development

- Distributed Algorithms and Services
- Data Broadcasting
- Indirect Protocols
- Location Management... Data Replication
- Location Dependent Mosaic
- Multicasting and Mobility
- Software Architectures and Programming Support

- Location - dependent Information Browsing
- Indirect TCP
- Exactly - once delivery of multicast messages to mobile hosts
- Pyramid broadcasting
- Energy - efficient data filtering

Applications Development

Infostations

- Information kiosks for mobile users with wireless connection
- services such as fax, e-mail, and web access

Satellite Information systems

- satellite based communication environments
- asymmetric data exchange protocols satellite - mobile users

Geographic messaging

- physical location (GPS) integrated to the current design of Internet (logical address).
- location dependent services such as geographic multicasting

Wireless Internet Services

- constraints of the mobile : energy, bandwidth, cost
- “environment aware “ support for e-mail, ftp, web access

The Dataman team is still small but has received significant funding.
Datamanプロジェクトのチームはまだ小さいが、かなりの出資を受けている。

Research Team

Thomasz Imielinski, Professor

B.R. Badrinath, Associate Professor

5 graduate students

Funding

Dataman research project is funded by government funding as well as industrial support:

- DARPA, GLOMO program,
  $1,625,000 for 1995 - 1998
- NSF
- WINLAB : Wireless Information Network Laboratory
  NSF/Industry University Cooperative Research Center at Rutgers University :

  65%: 30 industrial sponsors
  21%: Rutgers University subsidies
  14%: government grants

Research projects related to mobile computing are found at many other places.
モービル・コンピューティングに関するプロジェクトは、他にも多くの場所で行われている。

- University of Washington, “ Wit “, “ Mobisaic “, funding by NSF, Xerox
- Purdue, “ Science Pad “, “ Mowser “, “ Mobile Database “, etc., funding from NSF, DARPA, industry
- Columbia, Mobile Computing Lab, funding from NSF, DARPA
- University of Michigan, “ Little Work ‘
- University of Maryland, “ Mobile Computing and Multimedia Lab “
- Stanford, “ MosquitoNet “, funded in part by Xerox PARC
- UCLA, “ TRAVLER “, funding from DARPA

3 **Technology Categories, Research Areas and Projects**

3.1 **Technology Categories and Funding**

3.2 **Research Areas and Projects**

- Computer Systems
- Information Management
- Components
- Communications
- Intelligent Systems, HCI

3.3 **Conclusion and Lessons**

Research Areas and Projects - Components - Overview

The category of components is difficult to grasp because it is scattered across many disciplines and R&D often targets applications beyond computer systems.

コンポーネントの大分野は把握が難しい。研究領域は色々な部分に散らばり、研究の目的がコンピューターシステム以外の応用の場合もある。

Category and Definition	Technologies Regarded as Critical ...	... for national security	... for national competitiveness	Areas Recommended for Government R&D Funding by the CIC	Related DARPA ITO and ETO Programs	"Hot" Research Areas Interview Mentions, Unedited
Components **research in electronic components and materials that might be applied to a variety of systems, such as research in optoelectronics, mass data storage, video processing, bus systems, electromechanical systems, new materials, new production methods**	**parallel data storage:**		•	**parallel data storage :**	**microsystems**	• scalable parallel I/O
	• parallel data storage architectures	•	•	• parallel I/O architectures	• design technology	• holographic storage
	• parallel data storage controllers	•	•	• network-based mass data storage	• computational prototyping	• sensors
	high-density data storage:		•	**electronic circuits :**	• microarchitectures	• new materials
	• thin-film recording head **transducers**		•	• optoelectronics	**advanced lithography**	• micromachines
	• recording media		•	• interconnect systems	**analog/digital converter**	• molecular computing
	• high-density RAM	•	•	• integrating processing into components	**demonstration**	• computational semiconductor
	• format compatibility		•	• analog info processing	**display technologies**	prototyping
	• standards for optical storage		•	• molecular electronics	• high definition systems	
	• magneto-optical storage		•	• nanotechnology	• head mounted displays	
	• holographic optical elements		•	• biology-based computing components	**electronic packaging and**	
	high-definition displays:		•	• optical components and systems	**interconnect**	
	• lithography	•	•	**flat-panel and head-mounted displays** :	• physical electronic packaging	
	• micro/nano-fabrication	•	•	• electroluminesence	• application specific electronic modules	
	• circuitry patterning	•	•	• LCD	• multi-chip integration	
	• glass sheet production	•		• plasma	• high density microwave packaging	
	• thin-film techniques	•	•	• cold cathode	**high power electronics**	
	• holographic displays	•	•	**projection displays** :	**infrared focal plane array**	
	sensors:		•	• digital micromirrors	**integrated imaging sensors**	
	• microsensors	•	•	• LCD	**low power electronics**	
	• biosensors	•	•	• laser projection	**microelectromechanical systems**	
	• chemical sensors	•	•	**video processing** :	**microwave technologies**	
	• passive thermal imagers	•		• high-speed video processor modules	• microwave and millimeter wave	
	• point source passive thermal	•	•	• high-bandwidth video busses	**monolithic integrated circuits**	
	imaging systems		•	**component design and manufacturing :**	**• high density microwave packaging**	
	• high-yield high-density photo/IR	•	•	• design tools	**• microwave analog front-end**	
	detectors		•	• rapid prototyping	**technology**	
	• multi-spectral integr. sensors	•		• CAD synthesis algorithms	**optoelectronics**	
	• integrated signal processing in IR/	•	•	• modeling of devises/interconnects/packaging	**rapid prototyping of application**	
	radar sensors		•	• test theory/algorithms	**specific signal processors**	
	batteries:		•	• testbeds for comparing designs	**SEMATECH**	
	• lead-acid, lithium, aluminum-iron	•		• manufacturing automation	**tactical information assistants**	
	• sodium metal chloride, sodium sulfur	•	•	• complex physical device simulation	**ultra dense ultra fast computing**	
	• zinc-bromine, iron-air, zinc chloride	•	•	**energy storage :**	**components**	
	• iron-chromium, zinc-ferrocyanide, Li-	•	•	• high-density energy storage		
	Fe-S		•	**materials :**		
	materials:			• fundamentals of electronic materials		
	• ceramic IC packaging		•	**electromechanical systems**		
	• GaAs	•	•	**electromechanical assembly**		
	• thin-film dielectric materials	•	•	**merging of microelectronics and**		
	• semiconductor laser/faser arrays	•	•	**micromechanics**		
	• advanced photonic detectors	•	•			
	• biocompatible materials for	•	•			
	implantable devices					

source : National Critical Technologies Panel   source : CIC   source : DARPA   source : ADL interviews

While the " parallel " theme carries into the components category and made scalable Parallel I/O a hot area of current cutting - edge development, Computational Prototyping and Molecular Computing address issues that are likely to stay hot for a long time.

パラレル(並列)の考え方はコンポーネントの大分野にも当てはまり、スケーラブル・パラレルI/O(可変並列入出力)はホットな開発分野である。また、コンピューター・プロトタイピング(半導体製造用)と分子コンピューティングの分野は、これから長期的にホットであり続きそうな分野である。

Scalable Parallel I/O :

- the rising imbalance between system processing power and I/O and storage subsystems performance has made this a hot area particularly in development, but its lifecycle may be short

Computational Prototyping :
(of semiconductors)

- similar to software engineering, this area is becoming hotter as semiconductors get more varied but at the same time also more complex
- major issues are :
  - circuit - style impact on device and interconnect reliability
  - layout impact on cross - talk - induced signal degradation
  - critical device dimension variation

Molecular Computing :

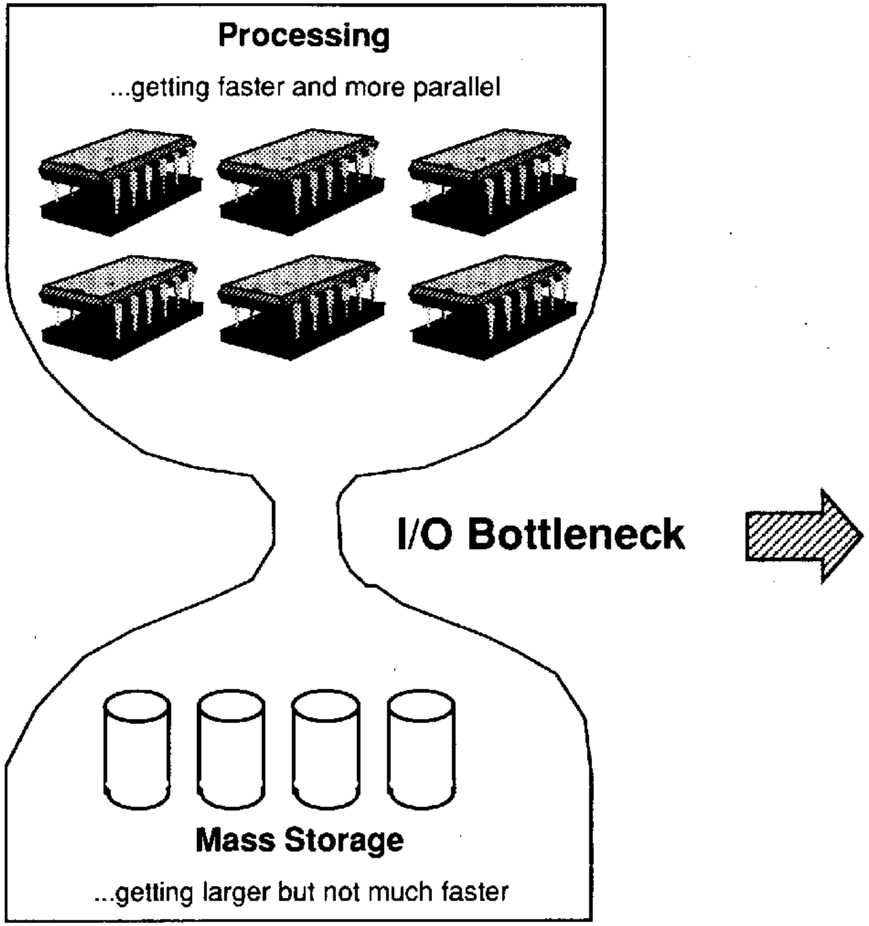
- molecular computing is regarded as an interesting very early stage research area with possibly high potential impact (e.g. Randy Katz , Ed Lazowska)

Other Areas :

- sensors are mentioned as a hot area (e.g. Paul Saffo) but this area is on the very fringe of IT
- while optical networking was regarded as hot (see Communications category) optical computing in general was not

The field of scalable parallel I/O is drawing significant attention as a component of high - performance computing at the moment because of the increasing imbalance between system processing power and I/O and storage system performance.

スケーラブル・パラレルI/Oの分野は、高性能コンピューティングのための一部分として、現在大きな注目を集めている。これはシステムの中で、CPUの演算速度向上に対して、記憶装置、入出力の側のパフォーマンスが遅れているためである。



Processing

...getting faster and more parallel

I/O Bottleneck

Mass Storage

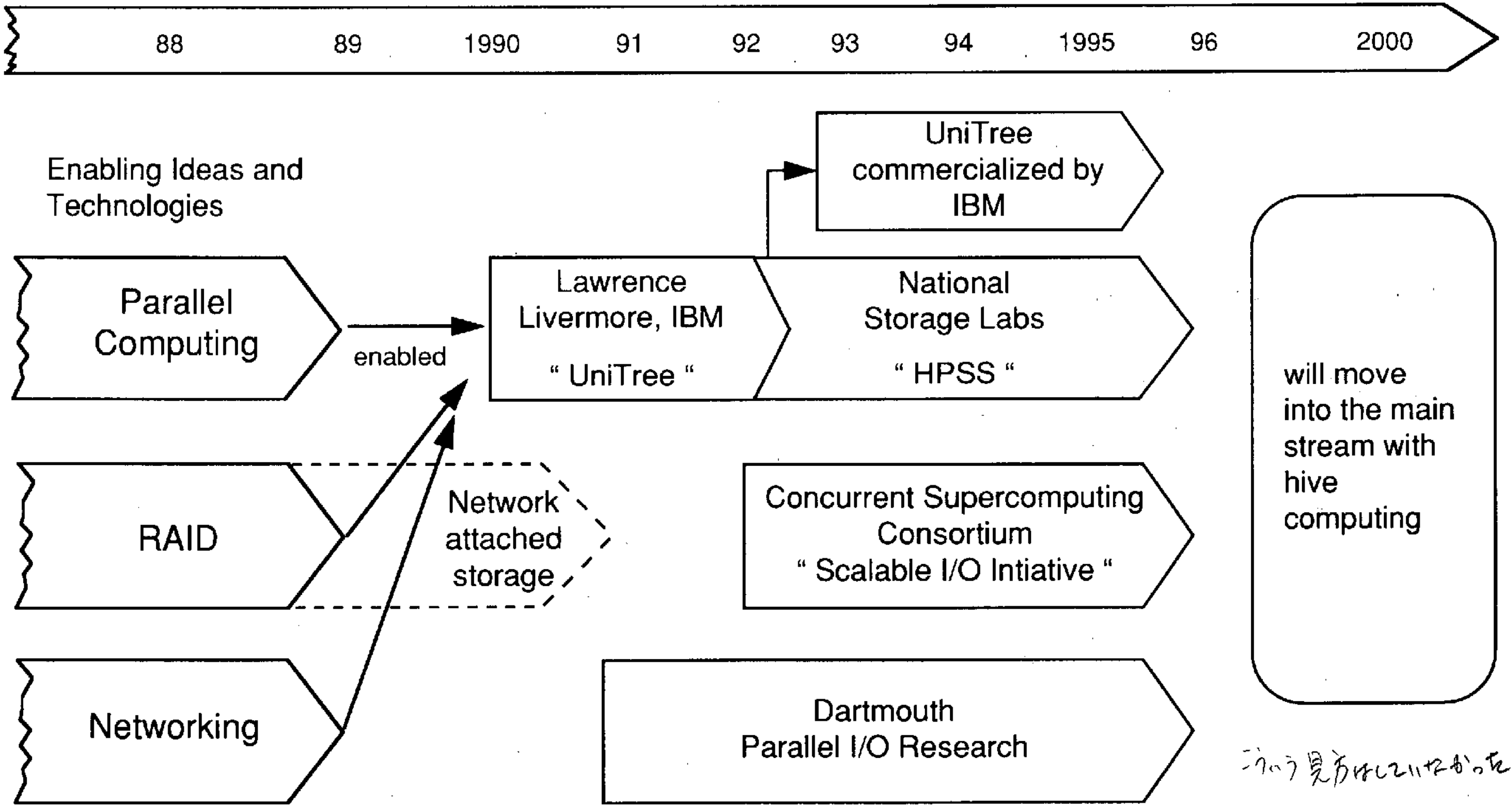
...getting larger but not much faster

Scalable, Parallel I/O

- parallel I/O
- parallel storage
- data striping
- separation of control and data paths
- network-attached peripherals
- direct peripheral - to - peripheral transfers

Scalable Parallel I/O - History

The national labs have played a prominent role in the history of scalable parallel I/O.
スケーラブル・パラレルI/Oの分野では、歴史的に国立の研究所が重要な役割を果たしてきた。



88 89 1990 91 92 93 94 1995 96 2000

Enabling Ideas and Technologies

Parallel Computing

RAID

Networking

enabled

Network attached storage

Lawrence Livermore, IBM
“ UniTree “

UniTree commercialized by IBM

National Storage Labs
“ HPSS “

Concurrent Supercomputing Consortium
“ Scalable I/O Intiative “

Dartmouth Parallel I/O Research

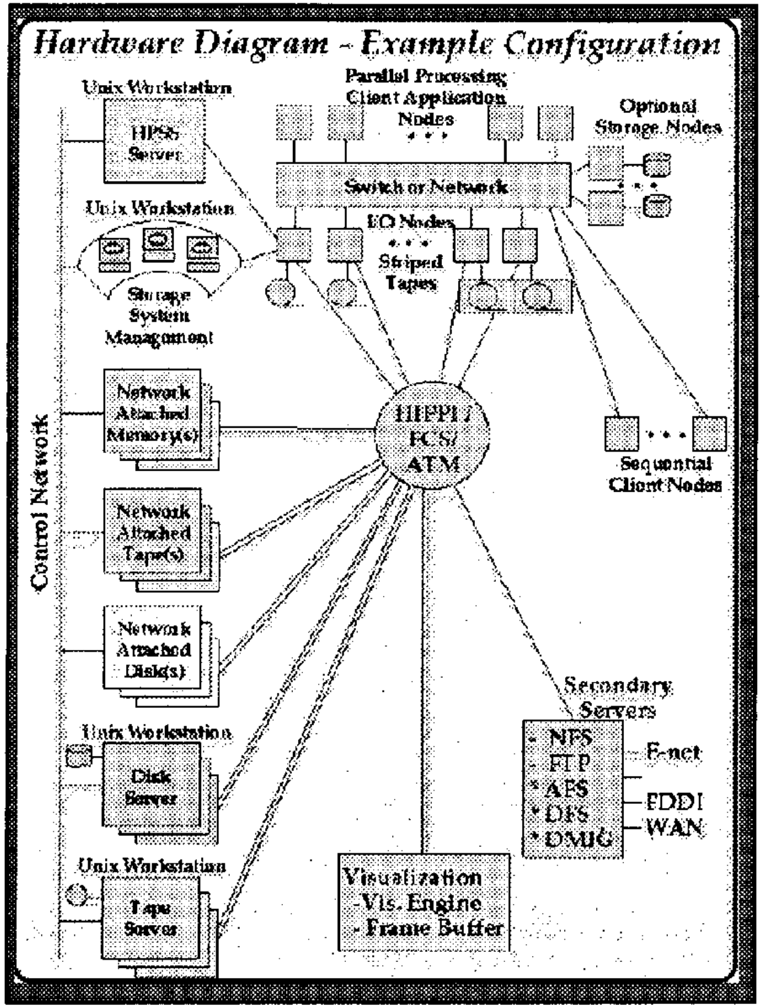
will move into the main stream with hive computing

こういう見方はしていなかった...

Scalable Parallel I/O - HPSS

The High-Performance Storage Systems (HPSS) project of the National Storage Lab (NSL) is developing a universal scalable parallel storage system for parallel computing architectures.

NSL(National Storage Lab)で行われているHPSS(High Performance Storage Systems)プロジェクトでは、パラレル処理アーキテクチャーのための汎用的スケーラブル・パラレル記憶装置を開発している。



石[illegible]さんへのMessage
に要るかもしれない

The goal of NSL's HPSS project is to develop an open, scalable, parallel storage system for use with workstation clusters, massively parallel computers, and traditional supercomputers. It's features are :

- (logically) separate network for data transfer and control
- supports both parallel and sequential I/O
- network-attached peripherals
- completely scalable, throughput limited only by network and peripheral capacity, not HPSS architecture
- currently supports HIPPI, FibreChannel, and ATM as networks, and can support others

The NSL is a collaboration between industry and government laboratories that evolved out of a CRADA* between IBM and DOE labs.

NSLはIBMとDOEのラボ間のCRADAによる産官協力から生まれた組織である。

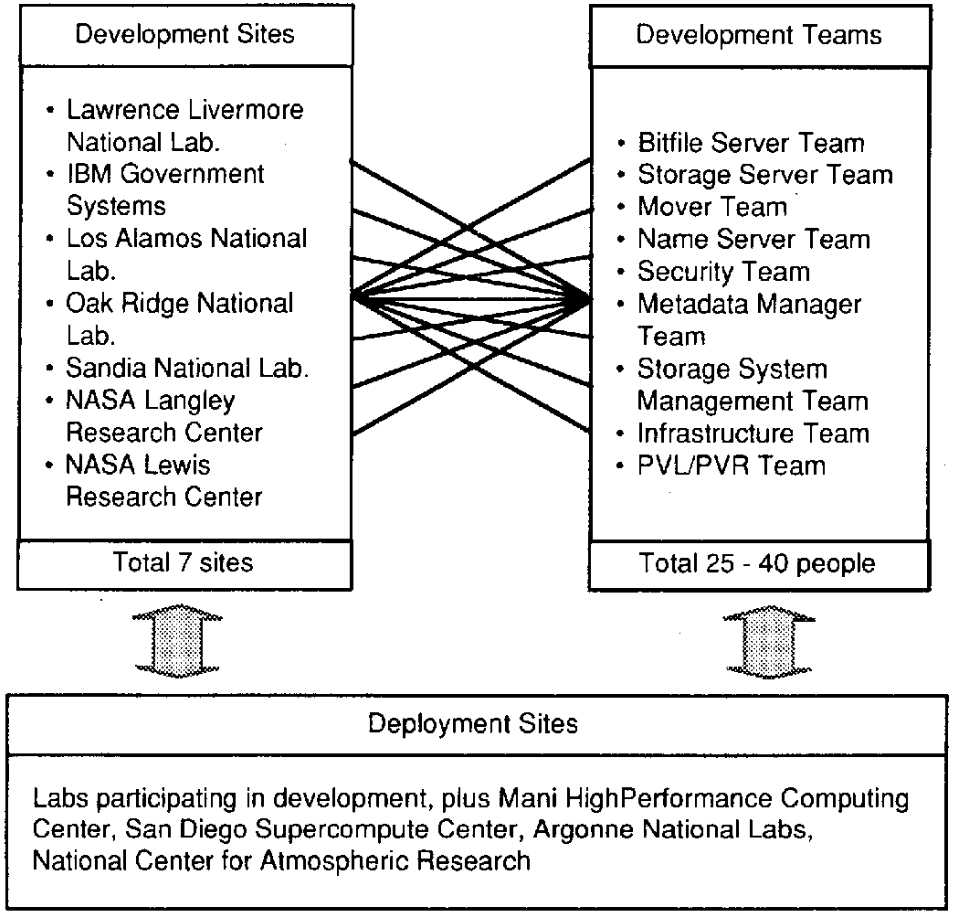
- mission is to investigate, demonstrate, and commercialize high - performance hardware and software storage technologies
- started as a CRADA between Lawrence Livermore's Richard Watson and IBM Government Systems for the development of the " UniTree " storage architecture
- other industry and government participants joined
- NASA now also has a particularly strong involvement
- HPSS is NSL's core project at the moment

* CRADA = Cooperative Research and Development Agreement

The HPSS project is broken down into several " virtual teams " whose members are distributed across development sites. Funding comes from DOE, NASA, and industry.

HPSSプロジェクトは幾つかのチームから構成され、それぞれのチームは色々な研究所に分散して活動するメンバーから成っている。資金はDOE、NASA、そして産業界から受けている。

Team Organization



Development Sites

- Lawrence Livermore National Lab.
- IBM Government Systems
- Los Alamos National Lab.
- Oak Ridge National Lab.
- Sandia National Lab.
- NASA Langley Research Center
- NASA Lewis Research Center

Total 7 sites

Development Teams

- Bitfile Server Team
- Storage Server Team
- Mover Team
- Name Server Team
- Security Team
- Metadata Manager Team
- Storage System Management Team
- Infrastructure Team
- PVL/PVR Team

Total 25 - 40 people

Deployment Sites

Labs participating in development, plus Mani HighPerformance Computing Center, San Diego Supercompute Center, Argonne National Labs, National Center for Atmospheric Research

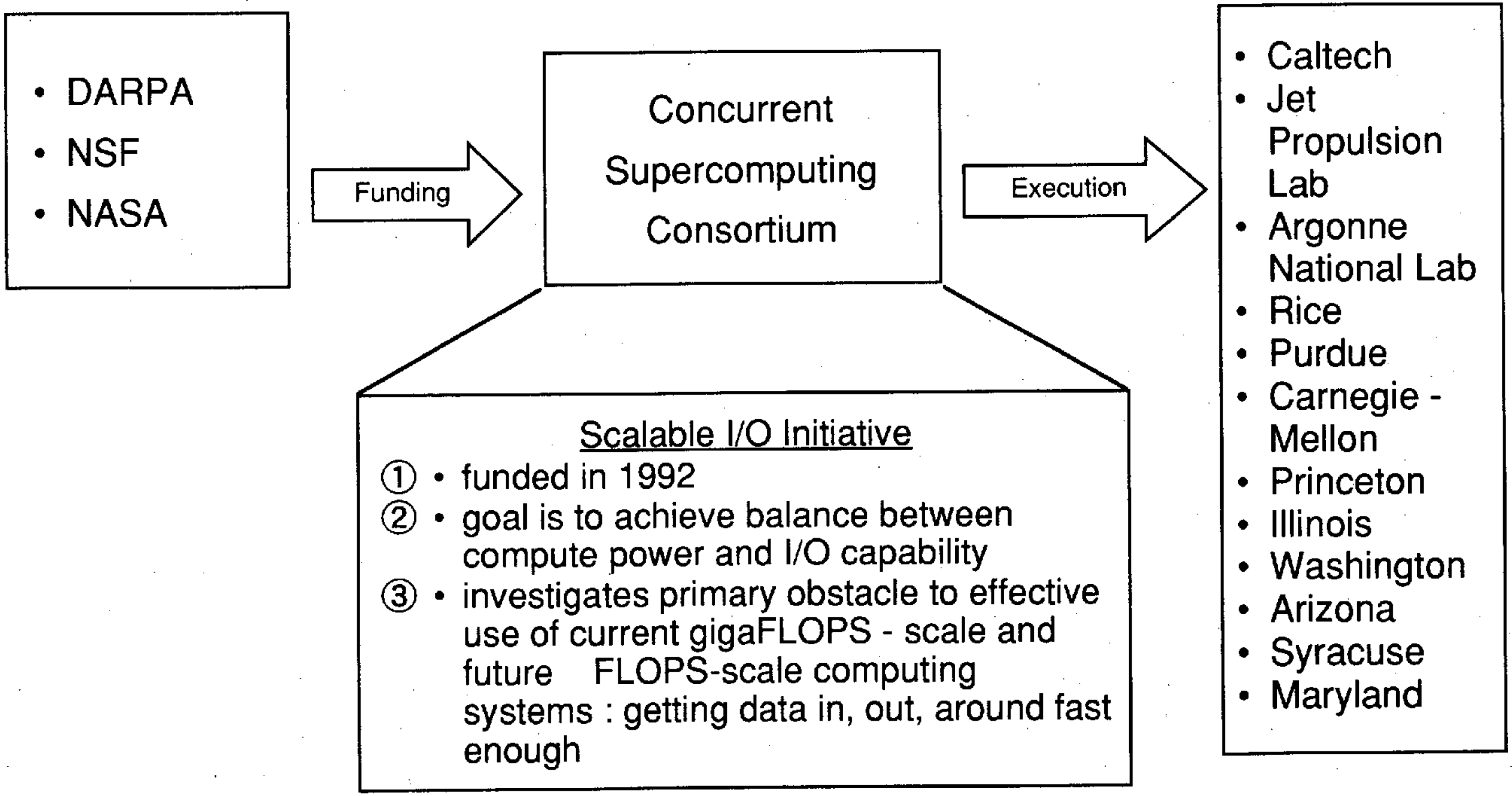
Funding, Sponsoring

- government funding by DOE, NASA
- industry participation by
  - IBM
  - Cray Research
  - Intel
  - Ampex
  - Network Systems Corp.
  - Kinesix
  - Maximum Strategy
  - Meiko
  - PSITech
  - Zitel

Scalable Parallel I/O - Scalable I/O initiative

The Scalable I/O Initiative is a collaboration between several universities, government labs, and industry under the umbrella of the Concurrent Supercomputing Consortium.

Scalable I/O Initiativeというプロジェクトは、Concurrent Supercomputing Consortiumという複数の大学、国立研究所、産業界の協力によるコンソーシアムの活動の一環として行われている。



- DARPA
- NSF
- NASA

Funding

Concurrent Supercomputing Consortium

Execution

- Caltech
- Jet Propulsion Lab
- Argonne National Lab
- Rice
- Purdue
- Carnegie - Mellon
- Princeton
- Illinois
- Washington
- Arizona
- Syracuse
- Maryland

Scalable I/O Initiative

① • funded in 1992

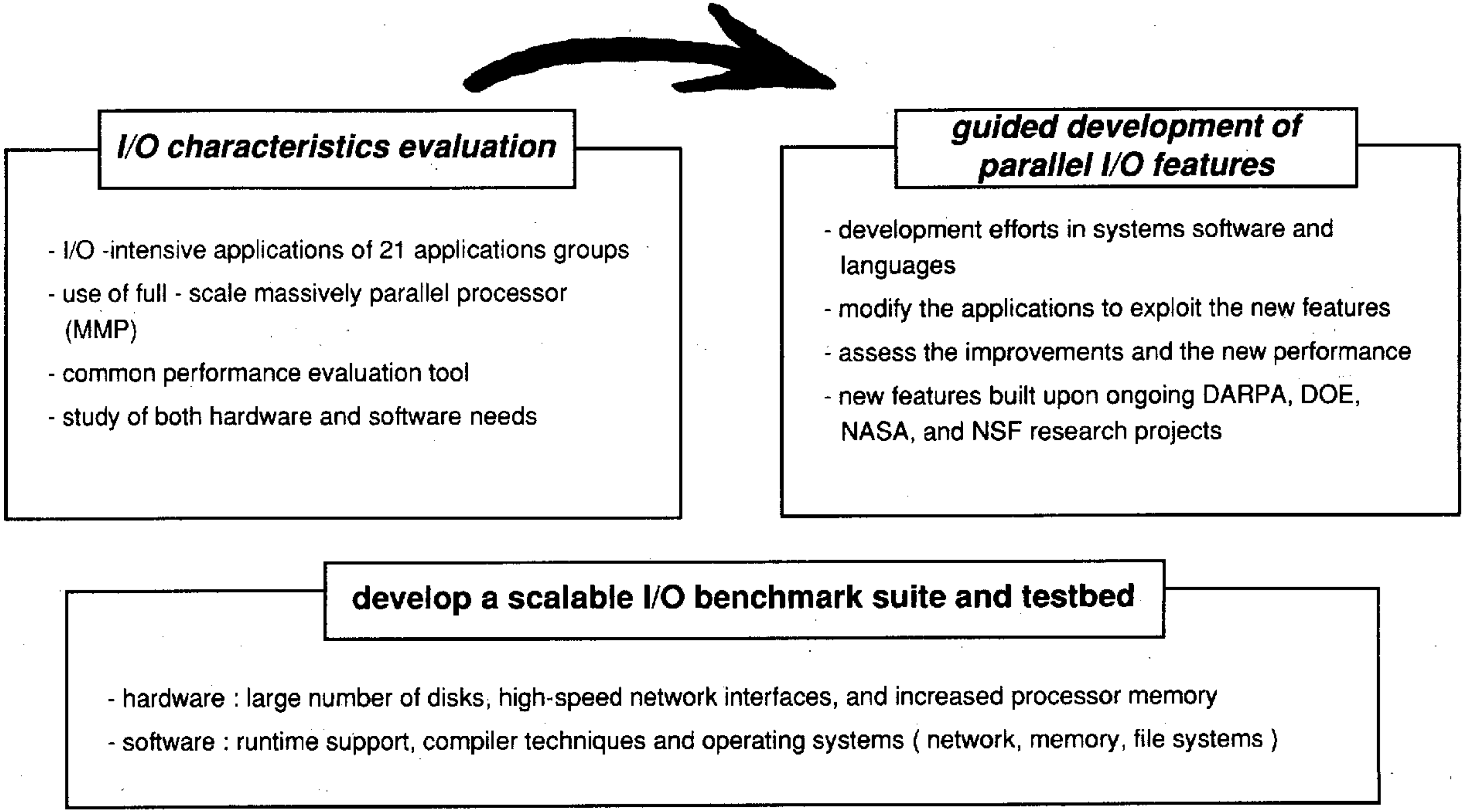
② • goal is to achieve balance between compute power and I/O capability

③ • investigates primary obstacle to effective use of current gigaFLOPS - scale and future FLOPS-scale computing systems : getting data in, out, around fast enough

Scalable Parallel I/O - Scalable I/O Initiative - Research Goals

A opposed to HPSS which is focused on massive data systems, the Scalable I/O Initiative adopts a system-wide perspective to analyze and enhance the diverse, intertwined system software components influencing I/O performance.

HPSSが大量データの記憶装置システムに注力しているのに対し、Scalable I/O Initiativeでは、入出力のパフォーマンスを改善するシステムソフトウェアの開発に力を置いている。



I/O characteristics evaluation

- I/O -intensive applications of 21 applications groups
- use of full - scale massively parallel processor (MMP)
- common performance evaluation tool
- study of both hardware and software needs

guided development of parallel I/O features

- development efforts in systems software and languages
- modify the applications to exploit the new features
- assess the improvements and the new performance
- new features built upon ongoing DARPA, DOE, NASA, and NSF research projects

develop a scalable I/O benchmark suite and testbed

- hardware : large number of disks, high-speed network interfaces, and increased processor memory
- software : runtime support, compiler techniques and operating systems (network, memory, file systems)

Scalable Parallel I/O - Scalable I/O Initiative - Team and Funding

A large number of researchers, scientists, and managers from research and academic institutions, industry, and government agencies are involved to ensure not only the efficiency, scalability and portability of the resulting techniques, but also the adoption of these results by vendors and users.

多数の研究者やマネジャーが政府省庁、大学・研究所、産業界から参加し、この技術の技術的完成だけでなく、その結果の産業での採用、ユーザーの利用に関してまで協議がされている。

DARPA, DOE, NASA, NSF sponsored Consortium

30 institutions in 14 states

Team Organization

Management team
led by Paul Messina, Caltech

Technical Workgroups

- Applications
- Compilers & Languages
- Operating & File Systems
- Performance Evaluation
- Integration & Testbeds

Workshops
Conferences
Publications

Academic

Argonne National Laboratory
Caltech
Carnegie-Mellon University
Purdue University
Princeton University
Rice University
Stanford University
Syracuse University
University of Arizona
University of Illinois
University of Maryland
University of Washington

Corporate

Cray Research
Convex
IBM
Intel SSD
NCSA
NASA Ames
NASA Goddard
NASA JPL
National Storage Lab
Pacific Northwest Lab
Silicon Graphics

Reseach into scalable parallel I/O occurs at many other places. NASA is particularly active in funding this area.

スケーラブル・パラレルI/O分野の研究は他の多くの場所でも行われている。NASAはこの分野に特に積極的な出資を行っている。

- Dartmouth, “ CHARISMA “ , “ Galley “, “ ViC * “, “ FLEET “, “ STARFISH “, funded by NASA, NSF
- Ames Research Center, works closely with Dartmouth and the SCII, NASA - funded
- Carnegie - Mellon, Parallel Data Lab, funding by NSF, NASA, NIST, industry consortium including DEC, HP, IBM, Seagate, Storage Technology Corp.
- Illinois, “ Pablo “, “ I/O Characterization “, funding by DARPA
- Syracuse, “ PASSION “ , funding by NSF, DARPA, Intel
- Duke, “ TPIO “, funding by NSF, Army

Computational prototyping of electronic components attempts to do for the manufacturing side of semiconductors what CAD did for the design side.

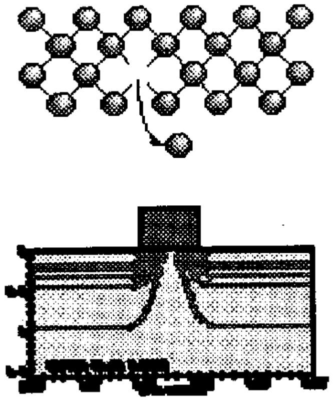
電子部品のコンピューター・プロトタイピングは半導体の製造を助けるもので、CADが設計を容易にしたように、製造の側を容易にしようという意図の研究である。

Problems

- increasing variety of designs
- with increasing complexity
- at decreasing scale
- lead to increasing costs for experimental prototyping
- which blows up capital requirements
- and slows down innovation

Computational Prototyping

Models + **Model Hierarchy**



Circuit Level

Device Level

Continuum Level

Mesoscopic Level

Atomic Level

input for a programmable factory

••• of circuits
••• of processes
••• of devices
••• of equipment
••• of factories

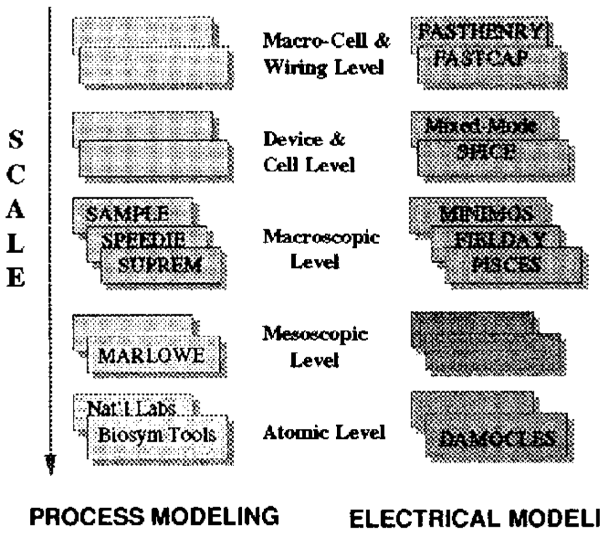
Computational Prototyping - CP21SS - Research Goals

The project "Computational Prototyping for 21st Century Semiconductor Structures" (CP21SS) at Stanford has a dual goal.

Stanford大学のCP21SS(Computational Prototyping for 21st Century Semiconductor Structures)プロジェクトは、2つの目標を持つ。

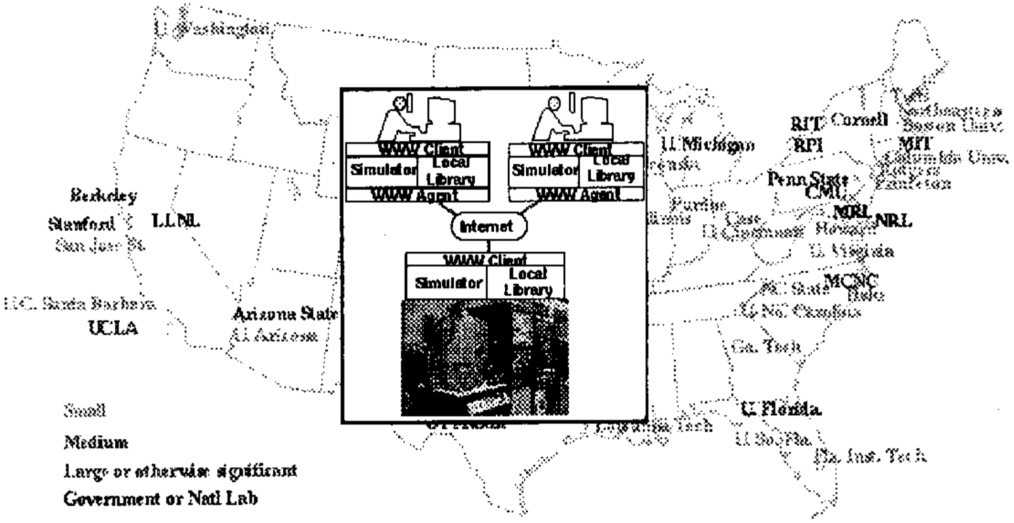
こういったことを
やっているところは日本には
少ないのでは
ないか？

Goal 1: Development of a Prototyping Environment



- develop physically-based models, including atomic-level effects
- develop a hierarchy of models
- implement and demonstrate a highly modular, open simulation environment

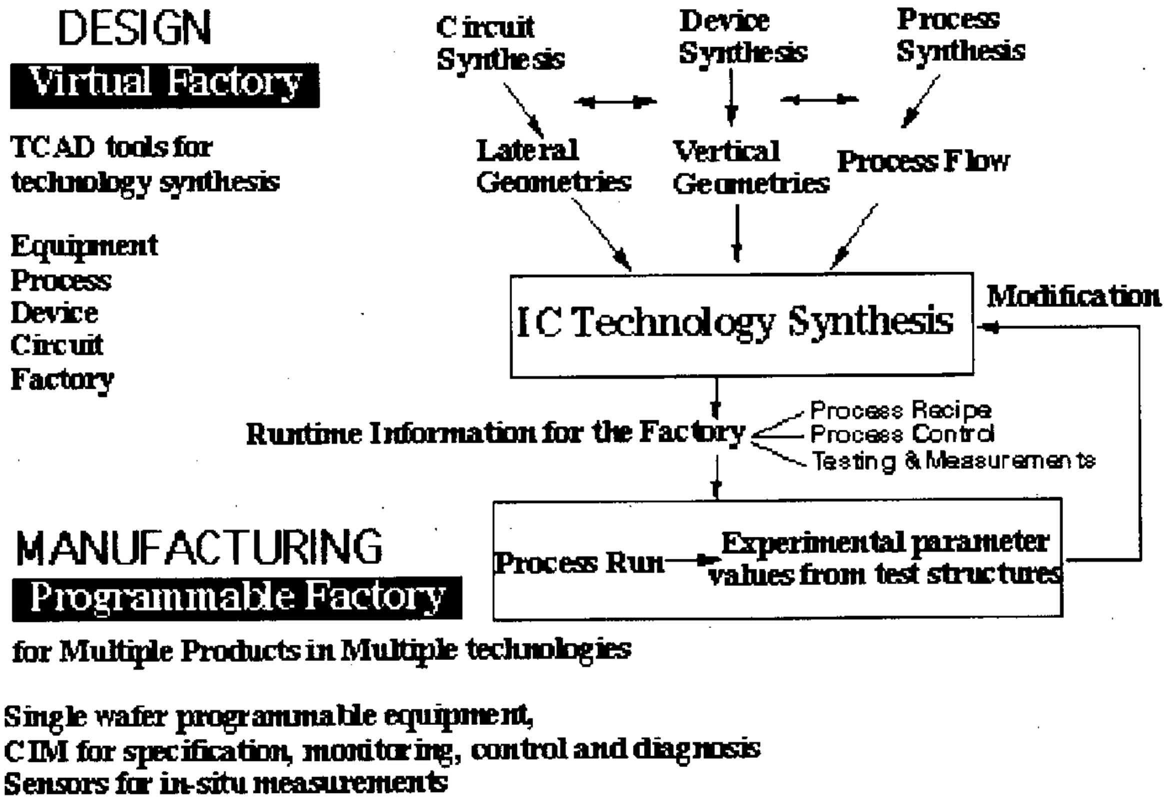
Goal 2: Organization of a National Network



- Organize and enable resource sharing of software models and unique equipment via collaboration over the Internet

The CP21SS project has grown out of the longer-term “Semiconductor Manufacturing for the 21st Century” interdisciplinary program at Stanford.

CP21SSは、Stanford大学の「21世紀の半導体製造」という、より長期視野のプログラムから派生したプロジェクトである。



DESIGN

Virtual Factory

TCAD tools for technology synthesis

Equipment
Process
Device
Circuit
Factory

MANUFACTURING

Programmable Factory

for Multiple Products in Multiple technologies

Single wafer programmable equipment,
CIM for specification, monitoring, control and diagnosis
Sensors for in-situ measurements

- place a “virtual factory” in parallel with a programmable computer-controlled factory
- prototype ICs computationally in the virtual factory as far as possible
- use programmable factory only to obtain experimental parameter values that cannot yet be covered in the virtual factory

Computational Prototyping -- Research Teams, Funding

CP21SS is a part of a collaborative year research program sponsored by DARPA. Over 40 academic research laboratories have expressed interest in building a National Network and joining this project.

CP21SSプロジェクトは、DARPAの年限共同研究プログラムの一環となっている。40以上の研究機関がこのプロジェクトに参画したい意思を表示している。

5-year-program funded by DARPA

Stanford University
Prof. James D. Plummer
Pro. Robert Dutton
8 faculty, 30 student

MIT Microsystems Technology Laboratories

Enterprise Integration Technologies, Inc.

Intel Corporation

Hewlett-Packard Company

Semiconductor Research Laboratories interested in building a National Network supported by NSF

Large academic Laboratories	**Government or National Laboratories**
Cornell	Lawrence Livermore National Lab.
Berkeley	Naval research Laboratory
MCNC	Sandia
MIT	
UCLA	
University of Michigan	
University of Austin	

The emerging field of molecular computing is based on the idea of using DNA to compute on a molecular scale.

分子コンピューティングの分野は、DNAを使って分子レベルで演算を行うという発想から生まれてきた。

(Simplified) Example : Using DNA to Solve a Traveling Salesman Problem

Problem:

- 4 cities need to be visited :
  - Atlanta
  - Baltimore
  - Chicago
  - Detroit
- 4 nonstop flights exist :
  - Atlanta - Chicago
  - Chicago - Detroit
  - Chicago - Baltimore
  - Baltimore - Detroit
- find a route starting in Atlanta, ending in Detroit and stopping in each city no more than once

Solution :

- assign a random, unique DNA sequence to each city name and a DNA sequence derived from the city sequences for each flight pair
- synthesize a large number of these DNA strands through genetic engineering and mix them together ; they recombine in various patterns
- filter out those recombined strands that don't start with " Atlanta ", that don't end in " Detroit ", or that don't include all' four cities ; this is done through techniques like affinity separation or polymerize chain reaction
- the remaining strands all contain valid solutions to the problem

Results :

- the manual processes of engineering the initial DNA strands and filtering out the invalid recombinations were time consuming
- the recombinatory process of the DNA itself, however, took less than a second, making it about 100 times faster than the fastest supercomputers
- the process was also a billion times more energy - efficient and its storage capabilities were a trillion times denser than today's storage media

⇨ The basic idea has since been extended in theory to a universal molecular computer.

Molecular Computing - Projects, Places, People

The conception of the field is generally credited to Leonard Adleman at the University of Southern California. Another emerging focal point is Richard Lipton at Princeton University.

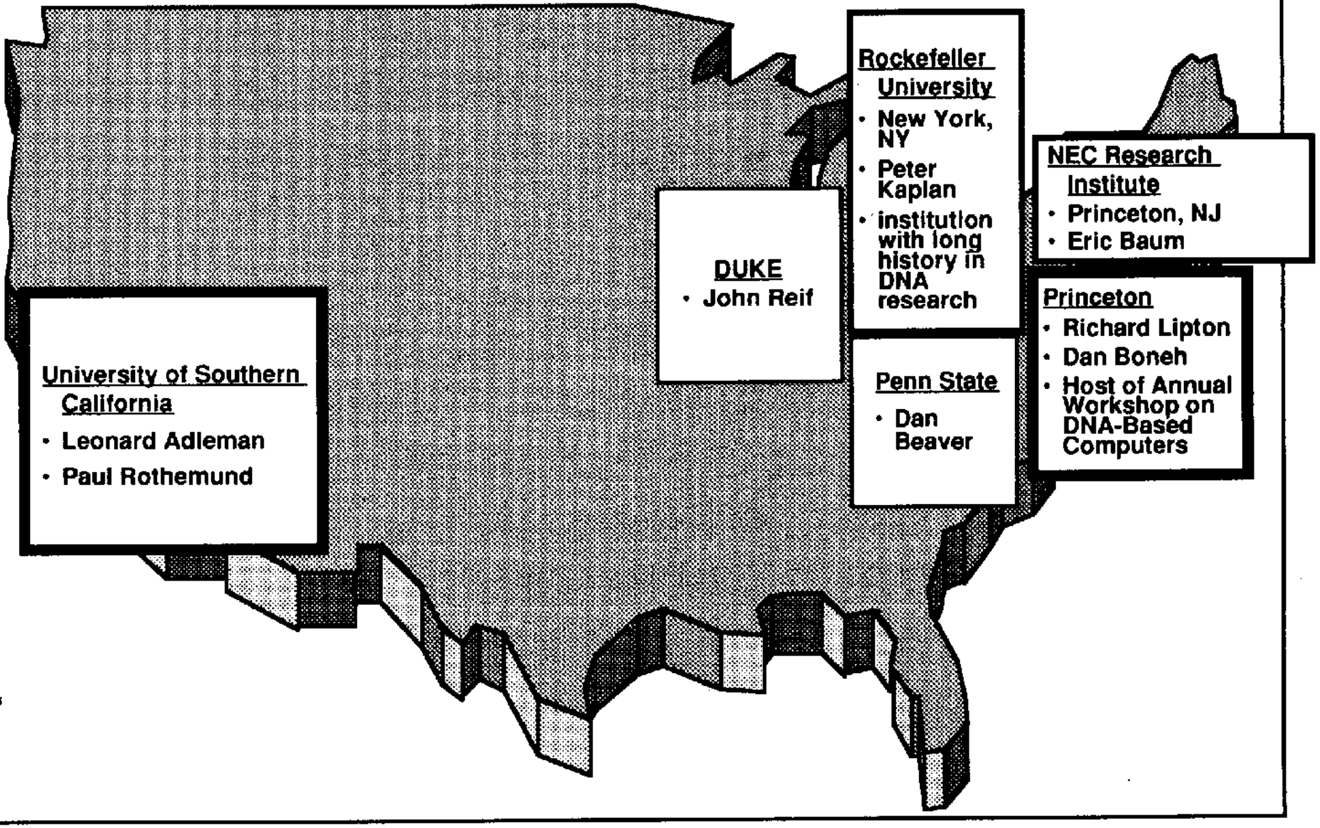
一般にこの分野の創始者はSouthern California大学のLeonard Adleman教授とされている。もう一つの中心となっているグループは、Princeton大学のRichard Lipton教授の所である。

Leonard Adleman

- Professor of computer science at University of Southern California at Los Angeles
- started the field with his paper " Molecular Computation of Solutions to Combinational Problems " in Science Nov.11, 1994
- previously co-invented the RSA* cryptography method and started the company of the same name (1978, 1982)
- coined the term computer virus (1983)

Richard Lipton

- Professor of computer science at Princeton University
- described the first scheme for a universal molecular computer in " Speeding Up Computation via Molecular Biology ' in 12 / 94



University of Southern California
- **Leonard Adleman**
- **Paul Rothemund**

DUKE
- **John Reif**

Rockefeller University
- **New York, NY**
- **Peter Kaplan**
- **institution with long history in DNA research**

Penn State
- **Dan Beaver**

NEC Research Institute
- **Princeton, NJ**
- **Eric Baum**

Princeton
- **Richard Lipton**
- **Dan Boneh**
- **Host of Annual Workshop on DNA-Based Computers**

---

* Rivest, Shamir and Adleman co-wrote the original algorithm

The idea of molecular computing is related to that of nanocomputing.
分子コンピューティングの考えは、ナノ・コンピューティングの分野とも関連している。

Nanocomputing Outline

- nanotechnology refers to the " bottom - up " manufacture of physical objects through the arrangement of atoms
- the theory is already quite well developed and there has been some initial small-scale experimental success, e.g. at IBM's Almaden Lab
- a computer built by means of nanotechnology, i.e. a " nanocomputer ", can be conceived as consisting of numerous nano-scale mechanical elements, such as sliding rods of atoms which are used to indicate 0 or 1 states
- a nanocomputer with the equivalent power of a large modern computer could be built in about the same volume as a single one of today's transistors in integrated circuits

Nanocomputing - Projects, Places, People

The fields of nanotechnology in general and nanocomputing in particular were established by Eric Drexler in 1981. Several nanotechnology centers have been established at universities and Japan is also quite active in this area.

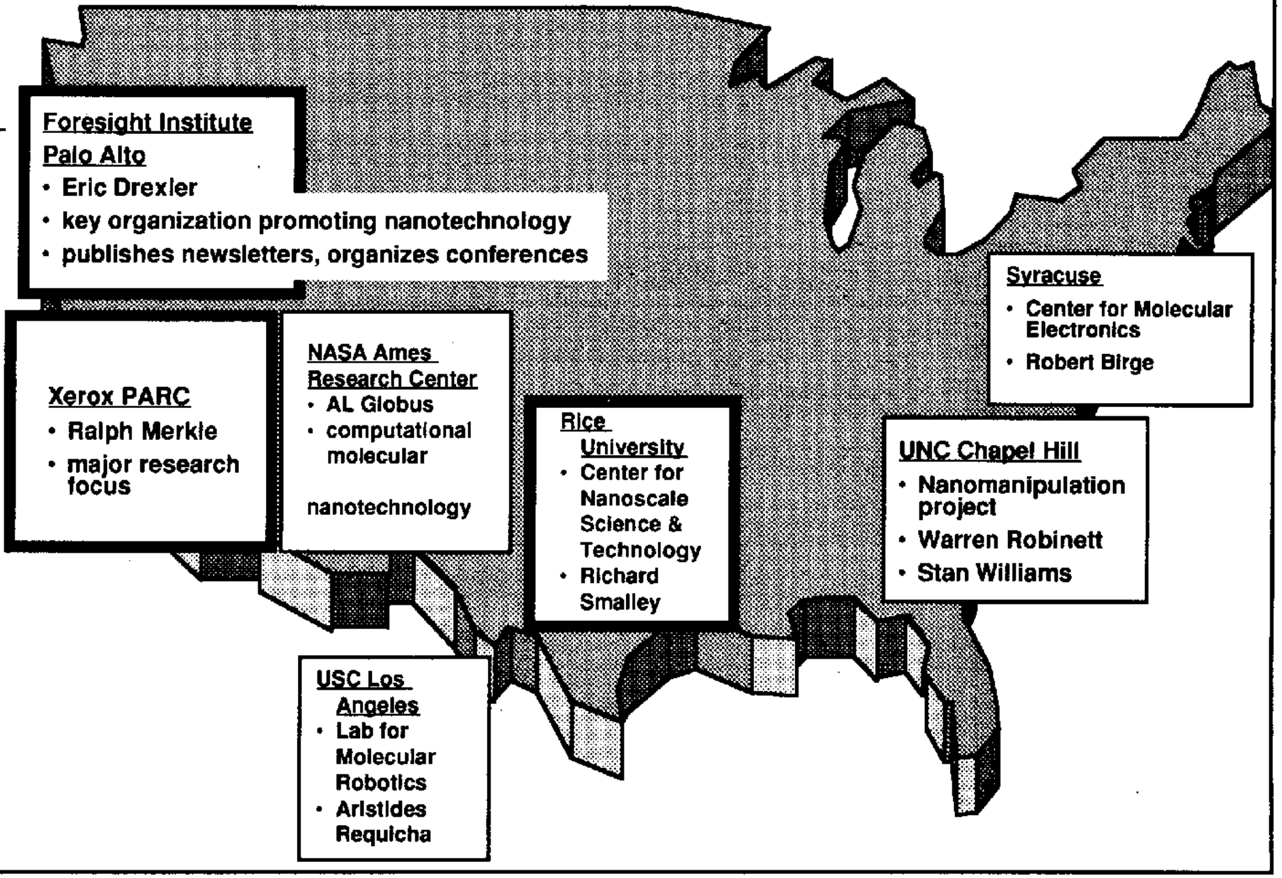
ナノレベル技術、特にナノ・コンピューティングの分野は、Eric Drexlerにより1981年に始まった。それからナノレベル技術の研究は幾つかの大学で行われるようになり、日本もこの分野で活発である。

Eric Drexler

- Head of the independent Foresight Institute, Palo Alto
- invented the concept of nanotechnology in 1981 at MIT
- author of " Nanosystems : Molecular Machinery, Manufacturing and Computation "

Ralph Merkle

- Researcher at Xerox PARC
- executive editor of " Nanotechnology " journal
- frequent chair of Nanotechnology conferences
- previously co-invented public-key encryption with whitfield Diffie and Martin Hellman



Foresight Institute Palo Alto
- **Eric Drexler**
- **key organization promoting nanotechnology**
- **publishes newsletters, organizes conferences**

Xerox PARC
- **Ralph Merkle**
- **major research focus**

NASA Ames Research Center
- **AL Globus**
- **computational molecular nanotechnology**

Rice University
- **Center for Nanoscale Science & Technology**
- **Richard Smalley**

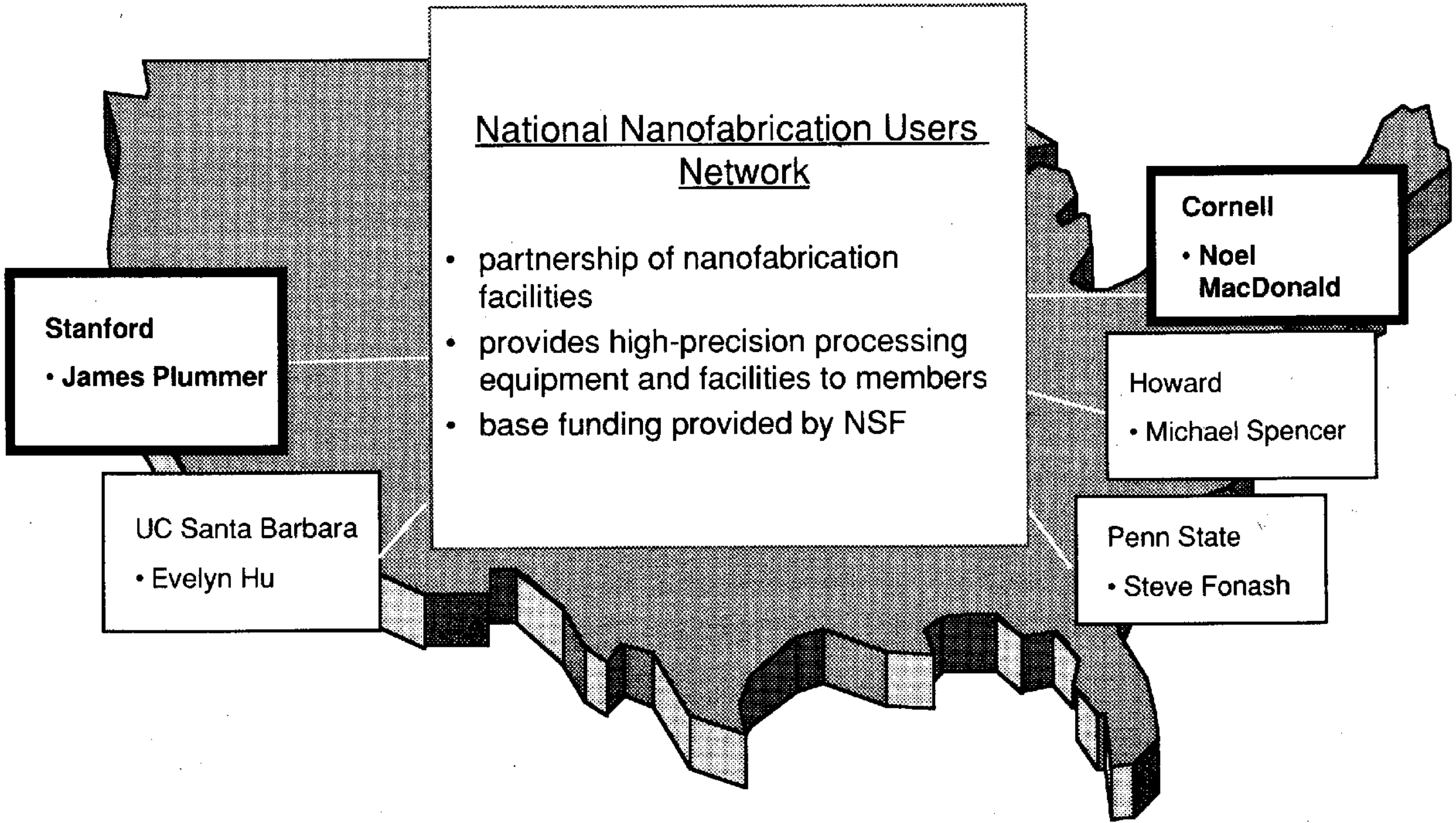
USC Los Angeles
- **Lab for Molecular Robotics**
- **Aristides Requicha**

Syracuse
- **Center for Molecular Electronics**
- **Robert Birge**

UNC Chapel Hill
- **Nanomanipulation project**
- **Warren Robinett**
- **Stan Williams**

The NSF is sponsoring the National Nanofabrication Users Network, a collaboration of five universities' nanofabrication centers.

NSFはNational Nanofabrication Users Networkという5大学の協力関係による研究に出資している。



National Nanofabrication Users Network

- partnership of nanofabrication facilities
- provides high-precision processing equipment and facilities to members
- base funding provided by NSF

Stanford

- **James Plummer**

UC Santa Barbara

- Evelyn Hu

Cornell

- **Noel MacDonald**

Howard

- Michael Spencer

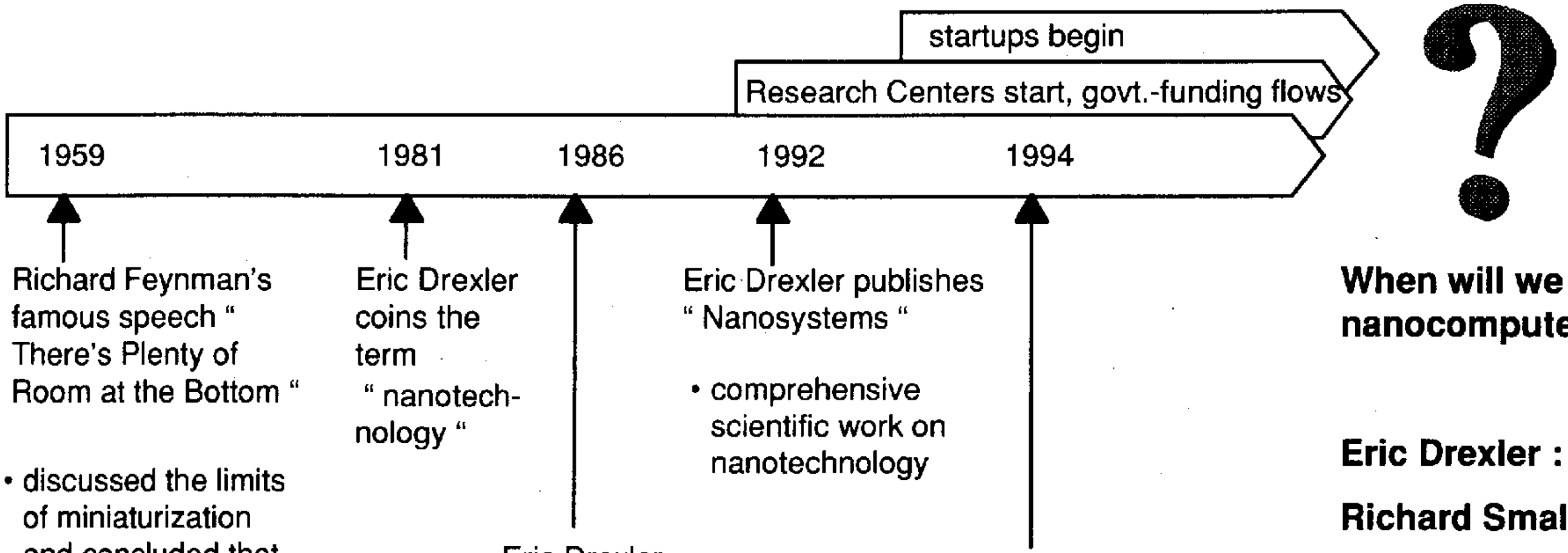
Penn State

- Steve Fonash

Molecular and Nano Computing - Timeline

Molecular and Nanocomputing have just started their life as research areas and experts do not expect a true, universal nano-scale computer for another 50 years.

分子コンピューティング及びナノ・コンピューティングともに、研究分野としてはまだ緒に付いたところで、専門家も汎用的なナノ・コンピューターができるのは数十年先との見方をしている。



startups begin

Research Centers start, govt.-funding flows

1959

Richard Feynman's famous speech " There's Plenty of Room at the Bottom "

- discussed the limits of miniaturization and concluded that in principle nothing prevents the rearrangement of atoms

1981

Eric Drexler coins the term " nanotechnology "

1986

Eric Drexler publishes " Engines of Creation "

- popularized the concept of nanotechnology
- outlined the concept of the " nanocomputer "

1992

Eric Drexler publishes " Nanosystems "

- comprehensive scientific work on nanotechnology

1994

Leonard Adleman invents DNA-Computing

When will we see a nanocomputer ?

Eric Drexler : 2017

Richard Smalley : 2100

Robert Birge : 2040

When will we see molecular memory ?

Bill Mitchell : 2010

Industryにしては…
チョット先すぎるという事ですね

3 **Technology Categories, Research Areas and Projects**

3.1 **Technology Categories and Funding**

3.2 **Research Areas and Projects**

- Computer Systems
- Information Management
- Components
- Communications
- Intelligent Systems, HCI

3.3 **Conclusion and Lessons**

The category of Human Interface and Intelligent Systems has seen a continuous shift of interest away from " artificial intelligence " as a research topic of its own good to a focus on improved human - computer interaction as the end toward which intelligent systems are just one contributing technology of many.

インテリジェントシステムとヒューマンインターフェイスの大分野では、研究の注力がAI(人工知能)から他に移行した。AI、あるいはインテリジェントシステム一般については、それはヒューマンインターフェイスを向上させるための一つの手段、一つの技術に過ぎないと見られている。

Category and Definition	Technologies Regarded as Critical ...	... for national security	... for national competitiveness	Areas Recommended for Government R&D Funding by the CIC	Related DARPA ITO and ETO Programs	"Hot" Research Areas Interview Mentions, Unedited
Human interface and intelligent systems **research in human interface and artificial intelligence problems, such as research in speech recognition, natural language understanding, robotics, adaptive systems**	**pattern recognition:** **• speech recognition** **• handwriting recognition** **• multimedia operating systems** **• VR software** **artificial intelligence:** **• natural language understanding** **• knowledge representation** **• computer-based reasoning** **methods** **• machine learning methods** **autonomous robotic devices:** **• sensors** **• signal processing** **• software** **• robotics**	 • • • •	 • • • • • •	**multimodal user interfaces :** • speech recognition • speech synthesis • visualization • VR (Virtual reality) • graphics tools • graphics standards **artificial intelligence :** • reason about task and collaborative process • common sense • human-term communication (spoken and written language, drawings, images, and gestures) • perception of physical environment • learning and adaptive behavior • large AI systems • integrated AI systems	**human computer interaction** **human language systems** **artificial neural network technology**	• multimodal user interfaces • speech • natural language processing • natural language understanding • translation • 3D graphics • virtual reality • telepresence

source : National Critical Technologies Panel   source : CIC   source : DARPA   source : ADL interviews

" AI was hot in the late 70s and in the 80s but it's now cold. In my opinion that's because first, people underestimated the problems and second, because the field moved away from the clearer and more creative thinkers like Marvin Minsky to sloppier people like Feigenbaum. "

(Paraphrase) Bob Taylor, currently at DEC SRC, formerly with DARPA and Xerox PARC

Hot research areas in human interfaces at the moment thus focus on multimodal interfaces, particularly human language aspects, and augmented and virtual reality.

ヒューマンインターフェイスの大分野で現在ホットなのは、マルチモーダル・インターフェイス、特に自然言語の面と、バーチャル・リアリティー(仮想現実)及び拡張現実感(Augmented Reality)である。

Multimodal Interfaces :

- human language interface aspects in particular continue to receive significant attention and funding and it is expected that these will continue their gradual penetration of more and more commercial markets over the next years
- the more exotic aspects, such as eye, lip, face, gesture tracking or facial animation attract attention in the research community but only limited government funds

RWCで使っているところ
この分野が‥‥

Virtual and Augmented Reality :

- in addition to virtual reality, augmented reality has begun to attract some attention as an early stage research topic
- this complements the focus on mobile and ubiquitous computing in the systems area

Other Areas:

- the " purer " side of AI, such as research in knowledge - representation, reasoning, or common sense was universally regarded as an "out" topic*
- the area of robotics was not examined in detail for this report but was not mentioned as a "hot" area by interviewees

roboticsは"hot"と言われてはいない。

---

* For further information on AI research please see Appendix

Carnegie - Mellon has developed into the academic center of focus for human - language interfaces.
Carnegie Mellon大学は人の自然言語インターフェイスの面で、学界研究の中心となった。

Projects and Research

Center for Machine Translation

- spontaneous - speech speech-to-speech translation (JANUS)
- machine translation (KANT, PANGLOSS)
- developed Lycos search engine

Interactive Systems Laboratory

- continuous spelling recognition (NSpell)
- connectionist parsing
- multimodal interfaces (INTERACT, includes face and eye tracking, sound localization etc.)
- e-mail dictation, wearable translators,...

People, Funding, and Industry Applications

- **14 faculty, led by Raj Reddy**
- **more than 30 students**
- **funding from DARPA, NSF**
- **industry afflictions to Microsoft, Apple, Dragon Systems, Matsushita**

DARPA is also funding R&D at all of the major commercial developers of continuous speed recognition systems.

DARPAは産業界に対しても、連続的音声言語認識システムの開発に対して出資を行っている。

BBN	Dragon Systems	IBM	SRI / Corona
• developing improved robust speech recognition techniques through use of improved acoustic phonetic speech models, better adaptation techniques, domain - independent recognition, and parsimonious language models • team of ~10 people • cooperation with North - eastern University • commercialization through " HARK " products line	• is developing hierarchical analysis HMM speech recognition for PC systems • commercial impact through a wide range of speech recognition products under the " Dragon Dictate " Line	• is developing algorithms based on model combination techniques for addressing robustness problems in large - vocabulary, speaker - independent continuous speech recognition • team of 8 people • commercial impact through IBM speech recognition products, e.g. " Voice Type " • cooperates with BBN	• is developing consistency modeling techniques for various application s, such as speaker and channel mismatch and noisy speech • team of 7 people • commercial impact through SRI spin - off Corona Corp.

All DARPA funded

Many other groups are working on multimodal interfaces and receive both government and industry funding.

他の多くのグループでもマルチモーダル・インターフェイスの開発を行っており、政府や産業の出資を受けている。

- Stanford, Applied Speech Technology Lab, Center for the Study of Language and Information
- Oregon Graduate Institute, Center for Spoken Language Understanding
- M.I.T., Machine Listening Group (Media Lab) and Spoken Language Systems Group
- UCLA, Speech Processing and Audio Perception Lab
- UC Santa Cruz, Perceptual Science Lab
- Microsoft Speech Research Group

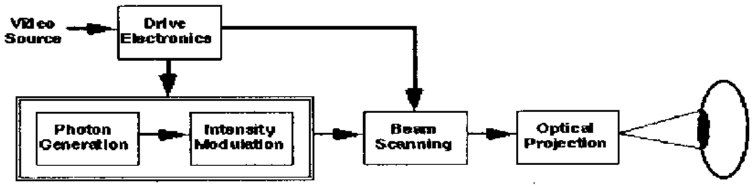
An increasingly hot research area closely related to both virtual reality and mobile computing is that of "augmented reality". Several places are concentrating on this area, with govt. funding coming particularly from DARPA.

バーチャル・リアリティーとモービル・コンピューティングの両方に大きく関係する分野として、拡張現実感の分野は段々ホットになってきている。幾つかの場所で研究は行われ、政府特にDARPAからの出資が付いている。

Carnegie - Mellon

- "VuMan" project
- create a prototype wearable computer for access to information in hands-free maintenance and operation environments
- work on hardware as well as software aspects
- led by Dan Siewiorek
- DARPA-funded

University of Washington



- Develop a prototype of a new, wearable display device in which a coherent light source is used to scan an image directly on a viewer's retina
- led by Thomas Furness
- 4-year sponsored research program funded by Micro Vision, Inc.

Columbia

- "KARMA" project
- develop a prototype wearable system for augmented reality in maintenance assistance
- "Architectural Anatomy" project
- expose a building's structure through augmented reality
- led by Steven Feiner
- various funding sources, including NSF

M.I.T.

- work on wearable computers and augmented reality centers around the combination with AI
- e.g. "Remembrance Agent" project by Bradley Rhodes and Thad Starner
- prototype implementation of a continuously running program which augments human memory by displaying a list of documents which might be relevant to the user's current context

Carnegie Mellon has been involved in the development of navigational mobile computers. Three generation of mobile computer architectures and products have been already developed and provide effective ways to improve productivity.

Carnegie Mellon大学はこの分野の中で、人の案内を行うモービルなコンピューターを開発してきた。3世代に亘るコンピューター・アーキテクチャーとプロトタイプの開発を既に行っており、それらは仕事の生産性向上に役立てられる。

Products

VuMan

wearable computers providing access to large database for reference while leaving hands free to perform the required physical operations.

- commercially available head-mounted see-through display
- interactive work : Hypertext, cursor, menus...
- handles only simple information
- uses a remote logistical computer

Navigator

more general purpose, the software and the hardware can be re-configured upon the applications.

- speech-input : 200 word vocabulary, will run real-time with an Intel 486-66Mhz

Issues

Rapid Design :

- collaboration with Berkeley and Stanford
- teams of up to 20 students for development, less than 4 months to design a prototype.

Human Computer Interaction :

- usability tests on one hundred subjects

Power Consumption :

- sets the amount of batteries (up to 70% of the weight)
- hardware / software improvement : gain factor up to 3

Progress : twice the capabilities than the first generation

- 1 / 4 complexity, weight, volume, power consumption
- 1 / 3 design / fabrication efforts and time
- withstands shock, temperature, water, and dirt

Applications :

CMU Campus Tour to Logistical Maintenance Computers

funded by DARPA Electronics Technology Office, DARPA Small Units Operations program

The Virtual Retina Display Project VRD at the University of Washington is located in a gray-zone between components and virtual and argumented reality.

Washington大学のVirtual Retina Displayプロジェクトは、コンポーネントの面とバーチャル・リアリティー及び拡張現実感の面の両分野にまたがる研究である。

organization

prototype developed under a 4 year program

Human Interface Technology Lab.
Univ. of Washington
(11 faculty and engineers)

funded by Micro Vision, Inc., which holds an exclusive license to manufacture and distribute the VRD

VRD characteristics

Fully inclusive or see- through display modes
Glasses mountable
Very low power consumption
Large field of view
High resolution, (almost human vision)
Full and better color resolution than displays
Brightness sufficient for outdoor use
Stereo display with depth modulation

Expected Impact

- recurring cost of the VRD system should be priced competitively with other displays
- demonstrate the ability to generate an inclusive, high resolution 3-D visual environment in a device the size of eyeglasses.
- applications : medical (e.g.surgery) manufacturing, communications and virtual reality

3 **Technology Categories, Research Areas and Projects**

3.1 **Technology Categories and Funding**

3.2 **Research Areas and Projects**

- Computer Systems
- Information Management
- Components
- Communications
- Intelligent Systems, HCI

3.3 **Conclusion and Lessons**

助けになる，とくに

Research Areas and Projects - Information Management - Overview

While government funding has been instrumental in the field of information management in the past, researchers have found it increasingly difficult in the 1990s to attract government funding.

過去には情報管理の分野に政府の出資も役立てられていたが、90年代に入って、出資を受けることは研究者にとって難しくなってきている。

Category and Definition	Technologies Regarded as Critical ...	... for national security	... for national competitiveness	Areas Recommended for Government R&D Funding by the CIC	Related DARPA ITO and ETO Programs	"Hot" Research Areas Interview Mentions, Unedited
Information management **research in information management systems, such as research in database design and management, query languages, transaction processing, logical and physical design**	**large-scale information systems:**			database design : • information creation, update, search, discovery, retrieval methods and tools • locating, filtering, integrating, and summarizing from distributed multimedia databases • content analysis and registration • dictionaries and indexes • logical and physical design schemata, particularly tools and techniques to design the schemata for efficient large-scale distributed databases composed of objects, relations, and legacy data • data compression and manipulation languages • query languages and processing • explicit profiles of user information requirements • transaction processing and concurrency • spatial data* • temporal data • multimedia data • imprecise data • active rules • integration of legacy systems	**• none** **a few HPCC digital library projects in...** **• defense technology integration and infrastructure** **• application support technology** **• technology and services validation**	• distributed and scalable databases • multimedia databases
	• very large database management tools	•	•			
	• real-time large-scale information retrieval tools	•	•			
	data fusion:					
	• multi-spectral data processing	•	•			
	• distributed array processing	•				
	network information systems:					
	• navigation and resource discovery tools		•			
	• directories		•			
	• registries		•			

source : National Critical Technologies Panel

source : CIC

source : DARPA

source : ADL interviews

* data distributed according to coordinates in a 3 - dimensional space. In this case data relating to geographical position

"Warm" research areas are found on the fringe of information management and the Internet.

そこそこホットな分野としては、インターネットとの関連での情報管理が挙げられる。

Distributed Multimedia Databases:

- are attracting some attention as a base technology for the national information infrastructure through the HPCC "Digital Library" program
- research focuses on issues such as:
  - replication in environments with frequent disconnections
  - queries on very slow devices
  - data integration
  - graceful degradation of multimedia data delivery

Multimedia Information Retrieval:

- similar to above
- key research issues are:
  - querying through multimedia input
  - visualization of massive multimedia data objects
  - concept retrieval of multimedia data

Other Areas:

- several other areas are regarded as hot in the information management research community but are finding it difficult to attract government funding:
  - data mining (extraction of information from large bodies of data that was usually collected for other purposes)
  - data warehousing (databases made of copies of data from one or more other databases)
  - workflow and transaction management
- the prevailing government opinion seems to be that these areas are sufficiently well served by R&D in the private sector

Government funded R&D into distributed multimedia databases and multimedia retrieval occurs mostly in the context of the HPCC "Digital Libraries" program.

分散マルチメディア・データベースとマルチメディア情報検索の分野への政府出資は、主にHPCCの「デジタル図書館」プログラムの一環として行われる。

Digital Libraries Are Different From Libraries...

Not a physical location with local copies; objects held closer to originators

Decoupling of storage, organization, access

Authorizing allowed! (organization, annotation, support for work groups)

Buying, pay-per-view supported in addition to browsing.

Integration into user tasks

Key Improvements with Digital libraries

Improve data captive via high accuracy transcriptions

Enable content-oriented access by applying natural language and vision techniques.

Address problems of scaling by applying and extending DBMS technology.

Facilitate distributed information access via better protocols, distributed search and resource discovery methods, and multi-resolution compression techniques.

Improve user access with new browsing paradigms and presentation techniques.

Perform user-based evaluation of the results

Provide a large number of geographically distributed users convenient access to the entire contents of very large and diverse repositories of electronic objects: text, images, maps, sounds, full-motion videos, merchandise catalogs, and scientific, and business data sets, as well as hypertextual multimedia compositions of such elements.

The Berkeley project aims at developing the technologies for intelligent access to massive, distributed collections comprising multiple terabyte databases of photographs, satellite images, videos, maps, full text documents, and "multivalent" documents.

UC Berkeleyのプロジェクトでは、数テラバイト規模の写真、ビデオ、地図や文書等の収集情報からなる超大量の分散データベースにアクセスできるようなインテリジェントな技術の開発を目指している。

Research Key Issues

- Integrate services into work practices
- Build prototype systems with real collections and users
- Develop technologies necessary for large-scale, distributed integrated information access systems
- Measure success by impact on world

Testbed : an Enviriomental Digital Library

- **Collection:**
  diverse material relevant to California's key habitats
- **Users:**
  consortium of state agencies, development corporations, private corporations, regional government alliances, educational institutions, and libraries
- **Systems:**
  low-tech system to make materials available quickly to participants; high-tech system deployed as research progresses
- **Potential:**
  basis for state-wide environmental system (CERES)

Berkeley's teams developed an integrated research plan focused on critical aspects of the technology needed for the full potential of digital libraries to emerge.

UC Berkeleyのチームでは、デジタル図書館の可能性を追及・実現するために、必要となる重要な技術面の研究を計画している。

Research goals

Providing a coherent, content-based view of a diverse distributed collection

Scaling to very large collections and large numbers of clients and servers

Data acquisition technology

research key points:

New paradigms of interaction

Fully automation indexing and intelligent retrieval

Developing data base technology to support electronic library applications

Developing a more effective protocol for client/server information retrieval

Developing resource discovery and distributed search algorithms

Applying a communications-theoretic approach to document analysis

Developing Compression and Communication for Remote Browsing

Implemented Prototype Systems

Low-tech: for quick availability

- "Dienst" server for Electronic library Technical Reports (ETRs - primarily environmental and government reports), aerial photos

(" Dienst", the server name, comes from the German word for 'service')

High-tech: for research progress

- CHABOT and CYPRESS: Data base access to photos via color specs
- TIOGA geo-positioned photo application
- "Big Sur" application to Delta GRASS, aerial and ground photos

This project is supported as part of the NSF/DARPA/NASA Digital Library Initiative, and as part of the California Environmental Resource Evaluation System (CERES) with $4 million over 4 years.

このプロジェクトはNSF、NASA、DARPAのデジタル図書館プログラムの一環として、またCalifornia Environmental Resource Evaluation System(州の環境資源評価システム)構築の一環として、4年間に亘り$400万の出資を受けている。

あまり大きな貢献
ではないが…

Federal Agencies

- NSF
- DARPA
- NASA

California Agencies and Organizations

- State of California
- CA Department of Water Resources
- CA Department of Fish and Game いきん類
- CA Environment Resources Evaluation
- CA Resources Agency
- CA State Library
- Sonoma County Library
- San Diego Association of Governments
- Shasta County Office of Education

Industrial Partners

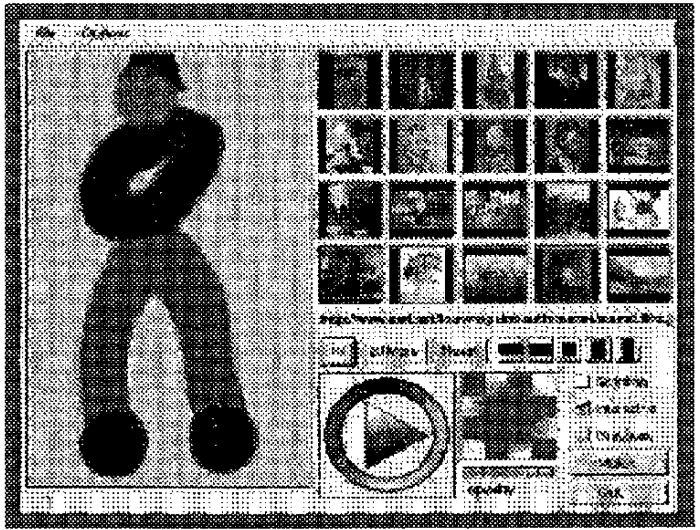
- Hewlett Packard Corporation
- Illustra
- IBM Almaden
- Philips Research
- The Plumas Corporation
- Rocoh California Research
- SAIC
- Sun Microsystems
- Xerox PARC

必ず顔を出してくる

(学生が多いと
いうこともあるんか??)

This project developed at the University of Washington explores a strategy for searching through an image database in which the query is expressed either as a low-resolution image from a scanner or video camera, or as a rough sketch painted by the user.

Washington大学のプロジェクトでは、画像データベースを検索するのに、ユーザーが粗い手書きの絵かスキャナー及びデジタルカメラで読み込んだ画像を入力として検索が行えるような方法を研究している。



これ Imageなどを入力して

Search する

(U of Washinton)

Method:

The searching algorithm makes use of multiresolution (wavelet) decompositions of the query and database images. The goal is to seek the database images which have their decomposition coefficients matching with the ones of the query.

User request:

expressed either by painting a crude picture or by showing an example of the image to a video camera or scanner. An interactive tool helps the user to refine his search.

Results:

median time to retrieve the target image: 1 second for a database of 10000 small images, 1 minute for large images. The algorithm is linear in the size of the database.

Application foreseen:

20,000 URLs for images have been collected on the Web. Tests are made to see how effective the method is for very large databases.

3 **Technology Categories, Research Areas and Projects**

3.1 **Technology Categories and Funding**

3.2 **Research Areas and Projects**

- Computer Systems
- Information Management
- Components
- Communications
- Intelligent Systems, HCI

3.3 **Conclusion and Lessons**

Research Areas and Projects - Communications - Overview

The category of communications is driven by the themes of high-speed networking, of mobile networks, and of information infrastructure services.

コミュニケーションの大分野では高速ネットワーキング、モービル・ネットワーキング、そして情報インフラサービスと言ったテーマに向かって研究が進められている。

Category and Definition	Technologies Regarded as Critical ...	... for national security	... for national competitiveness	Areas Recommended for Government R&D Funding by the CIC	Related DARPA ITO Programs	"Hot" Research Areas Interview Mentions, Unedited
Communications technology and information infrastructure services research advancing the state of computer communications hard- and software technology, such as research in high-speed networking, wireless services, network security	**telecom/data routing:**		•	**telecom/data routing:** • analog and digital wireless technology • micro to macro cellular systems • satellite technologies • scalable, reliable, adaptive routing algorithms that support mobility and enhanced multicast capabilities • nomadic computing and access • internetworking and interoperable services • network resource allocation and management • autonomous self-configuring network technology • evolution of legacy systems and applications • all-optical switching and transmission • 100 gbps available generally • tbps testbeds (trillion-bits-per-second) **data compression:** • encoding and compression techniques • image transmission over packet networks • high-bandwidth digitally compressed video and data transfer **information infrastructure services:** • ubiquitous, multi-domain, and multi-level security • identification • privacy • support for electronic commerce • universal accessibility • NII user affordability • ease-of-use • global interoperability • reliability • resource scheduling • load balancing • performance instrumentation • visualization	**networking systems** • internetworking • high performance networking • advanced developmental networking information survivability • high confidence networking broadband information technology • multiwavelength optical networking consortium • national transparent optical network consortium • WDM with electronic switching technology • IBM/Corning optical network • innovative device technology and solution-based TDM **defense technology integration and infrastructure** • application support technology • technology and services validation **global mobile infosystems** • modular multifunction wireless nodes • wireless node design technology • multi-hop network technology • mobile internetwork architecture • mobile application support	**• gigabit networking** **• all-optical networking** **• quantum optics** **• quantum photonics** **• embedded seamless fiber networks** **• signaling technology for last-mile problem** **• robust and mobile networks** **• wireless/mobile radio/RF** **• bandwidth management** **• information survivability**
	• broadband switching	•				
	• programmable radios	•	•			
	• wireless communications	•	•			
	• cable	•	•			
	• fibre	•	•			
	• satellite-ground communications protocols	•	•			
	• mobile computing systems	•	•			
	signal conditioning and validation	•	•			
	data compression:					
	• chaotic graphics compression	•	•			

Source: National Critical Technoloies Panel

Source: CIC

Source: DARPA

Source: ADL interviews

computer関係
あまりwireless
に目を向けてないの
[illegible]が…

The hot areas in communications R&D at the moment are Optical Networking, Mobile Networking, and High-confidence Networking

現在コミュニケーションの中でホットな分野は、光ネットワーキング、モービル・ネットワーキング、そしてネットワーク・セキュリティ(High-confidence networking)である。

Optical Networking:

- all-optical networking which avoids all opto-electronic conversion in the network to achieve performance levels of 100 Gbps and higher
- research issues are, for example,
  - space-switched transparent optical ATM networking
  - terahertz optical asymmetric demultiplexing
  - optical time-division multiplexing
  - self-routed photonic packet switching

Mobile Networking:

- issues related to wireless networking in mobile computing environments
- covered under "Computer Systems" category, (please refer to Computer System Section 3•2•1)

High-Confidence Networking:

- development of ubiquitous security mechanisms in routing, management, directory etc protocols
- hot R&D topics are, for example,
  - security-enhanced routers
  - authentication of nomadic hosts
  - micro transactions support
  - secure ATM communication

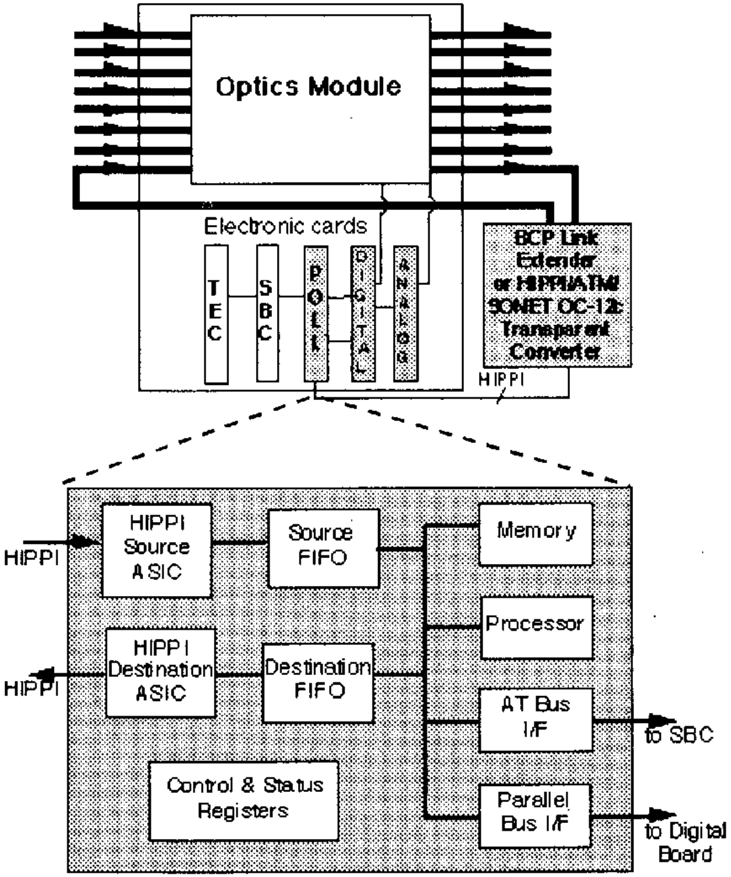
Other Areas:

- signaling technology for the last mile (ie between the Internet service provider's POP (Point of Presence) and the subscriber premises) was also mentioned as a research area with high impact (e.g. Gordon Bell)

The goal of the "All-Optical Gigabit LAN" project at Optivision is to develop and demonstrate end-to-end multi-format highly secure all-optical switched connections. It is a good example of an SBIR-funded project.

Optivision社の「完全光化ギガビットLAN」プロジェクトは、末端から末端まで全て光で交換も行われる高信頼性のネットワークを開発しようというものである。これは政府のSBIRプログラムによる出資の良い一例である。

IN-BAND CONTROL BLOCK DIAGRAM



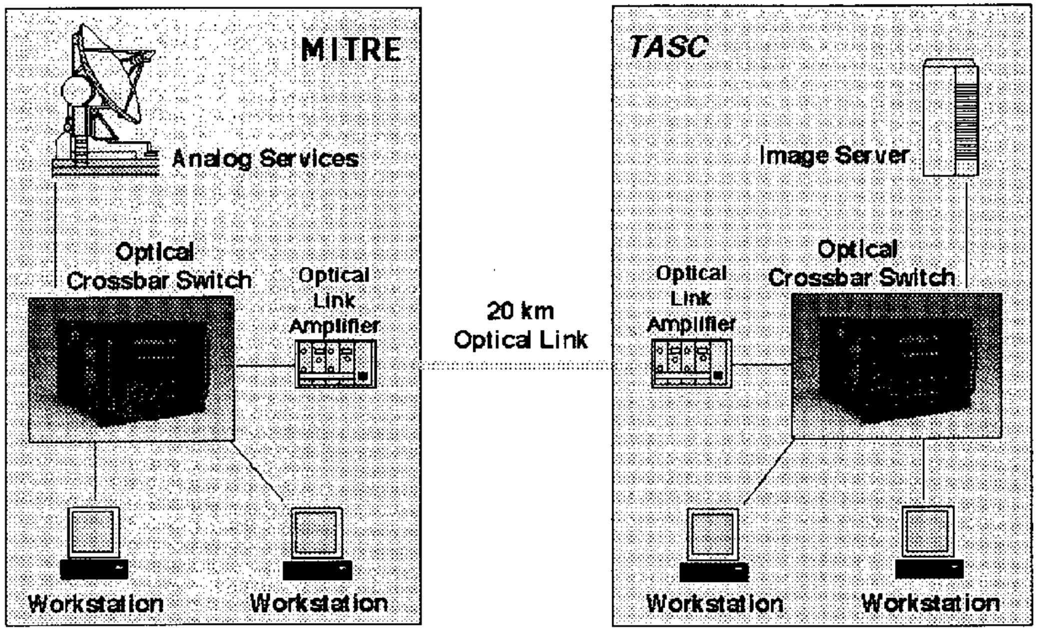
Tech Goals, Tech Overview

- research and develop control methods for optically switched networks
- focus on in-band control through a polling receiver that modifies the state of an optical crossbar switch based on changes in the connection state of incoming light streams
- develop HIPPI/ATM/SONET OC-12c transparent converter based on this technology

Funding, Commercialization

- performer is small company in Silicon Valley
- Funded by DARPA through SBIR
- developed products tested in DARPA-funded "TBONE" all-optical networking tested
- Optivision developing commercial product based on the prototype developed

Government also provides the funding for the TBONE testbed for all-optical networking
政府は完全光化ネットワーキングのためのTBONEプロジェクトテスト施設にも出資している。



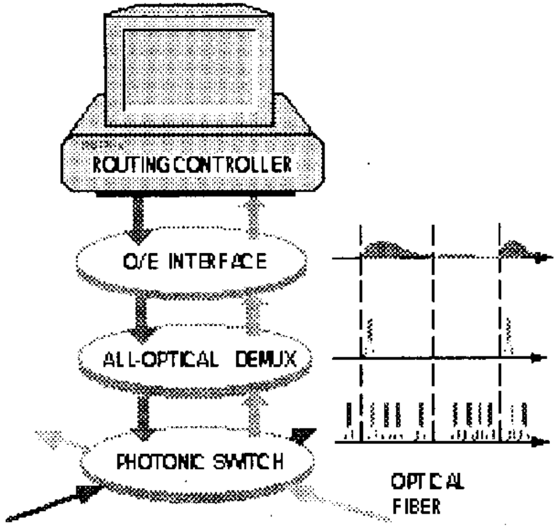
Collaboration between Optivision, MITRE, and TASC

- DARPA-funded testbed for all-optical networking
- two-switch all-optical metropolitan scale network
- research, develop, and compare out-of-band, in-band, and in-fiber out-of-band approaches to switching control
- Uses image-based applications for real-world performance evaluation

Princeton's 100 Gbps Optical Network project is designing a multihop, space-switched, transparent optical ATM network with real-time routing control at each node.

Princeton大学の100Gbps光ネットワークプロジェクトでは、マルチホップ方式、空間交換で、リアルタイム・ルート制御が各ノードで行える光ATMネットワークを設計している。

Project Technology



- Develops a terahertz optical asymmetric demultiplexer to eliminate all opto-electronic conversion at nodes
- optically-processed deflection routing to resolve packet contention
- 100 Gbps switching node, scalable in size and speed

Project Team

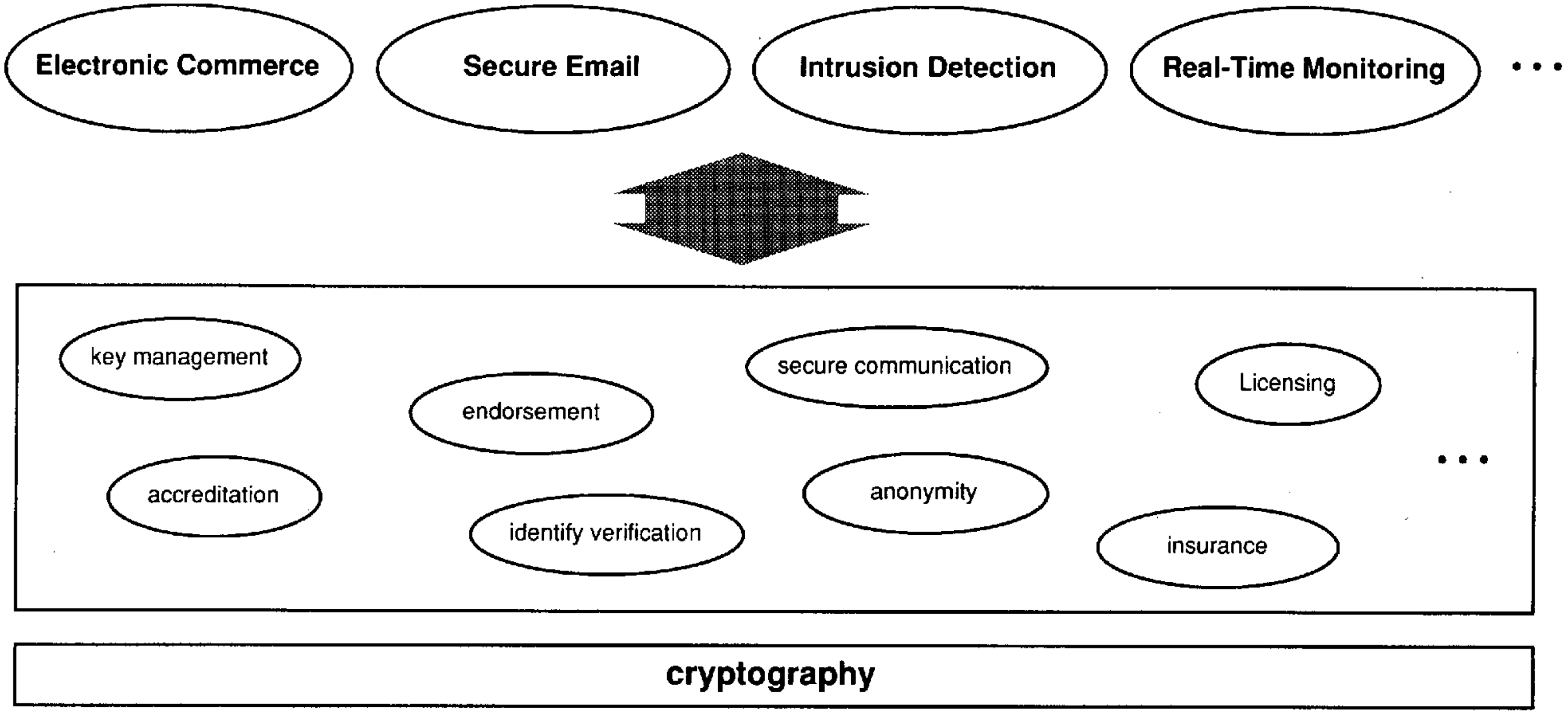
- 5 professors: Keren Bergman, Stephen Forrest, Hisashi Kobayashi, Paul Prucnal, Moti Seger
- 13 graduate students

Project Funding

- DARPA funded for minimum of 3 years
- industrial affiliates of Princeton's Advanced Technology Center for Photonics and Optoelectronic Materials

High-Confidence Networking has become an area of focus in communications R&D as public networks like the Internet play an increasingly critical role as the information infrastructure for business transaction as well as military communications.

ネットワーク・セキュリティは、インターネット等の公衆ネットワークが情報インフラとしてビジネスや軍事に重要性を増すにつれて、重要な研究開発分野となった。



Electronic Commerce

Secure Email

Intrusion Detection

Real-Time Monitoring

• • •

key management

endorsement

secure communication

Licensing

accreditation

identify verification

anonymity

insurance

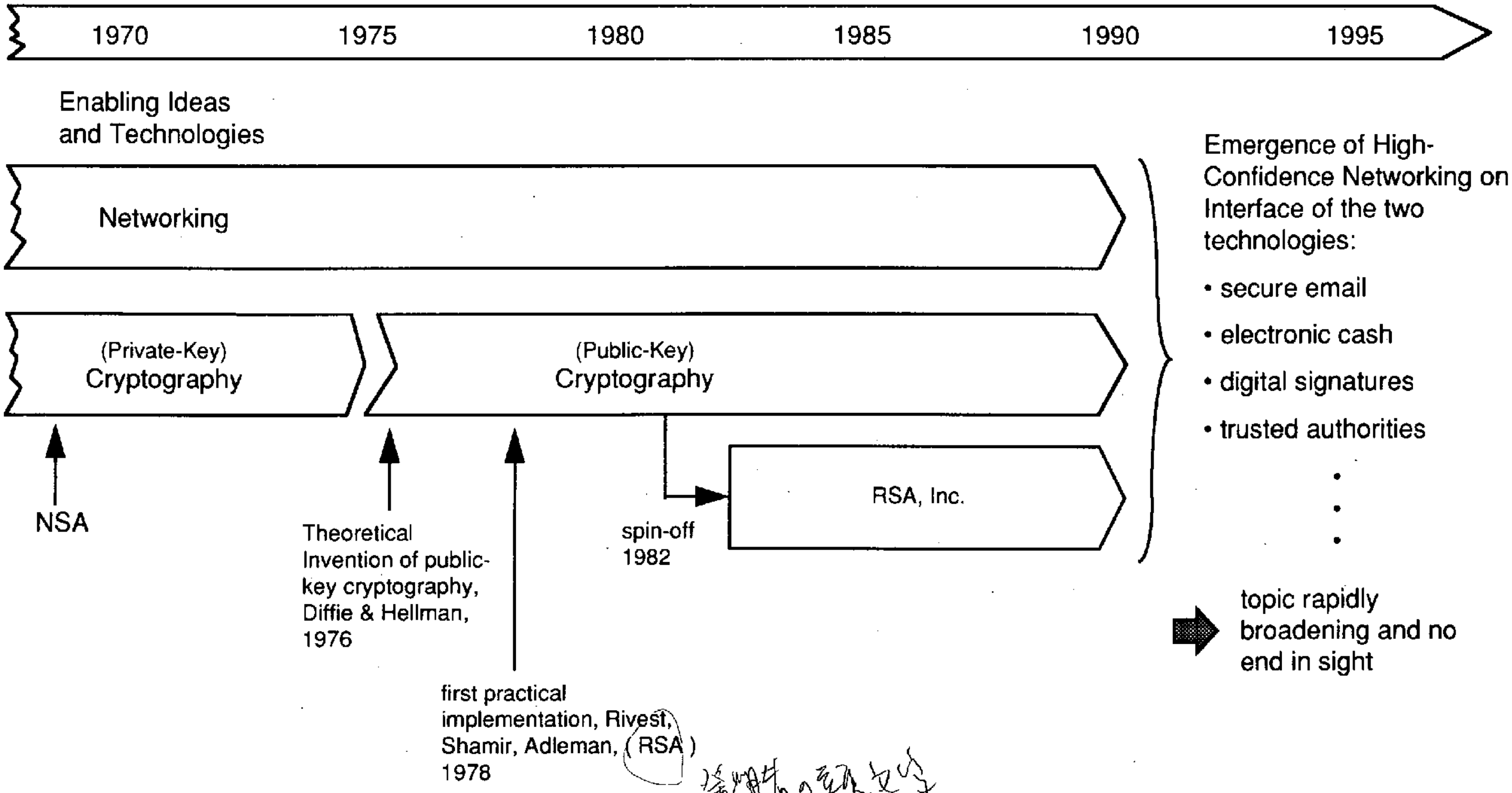
• • •

cryptography

Research Areas and Projects - Communications High-Confidence Networking - History

High-Confidence networking is historically roated in the combination of networking with public-key cryptography.

ネットワーク・セキュリティの研究は、ネットワーキングと公開キー暗号技術の両分野の研究から発生してきた。



1970 1975 1980 1985 1990 1995

Enabling Ideas and Technologies

Networking

(Private-Key) Cryptography

(Public-Key) Cryptography

RSA, Inc.

NSA

Theoretical Invention of public-key cryptography, Diffie & Hellman, 1976

first practical implementation, Rivest, Shamir, Adleman, (RSA) 1978

発明者の頭文字

spin-off 1982

Emergence of High-Confidence Networking on Interface of the two technologies:

- secure email
- electronic cash
- digital signatures
- trusted authorities

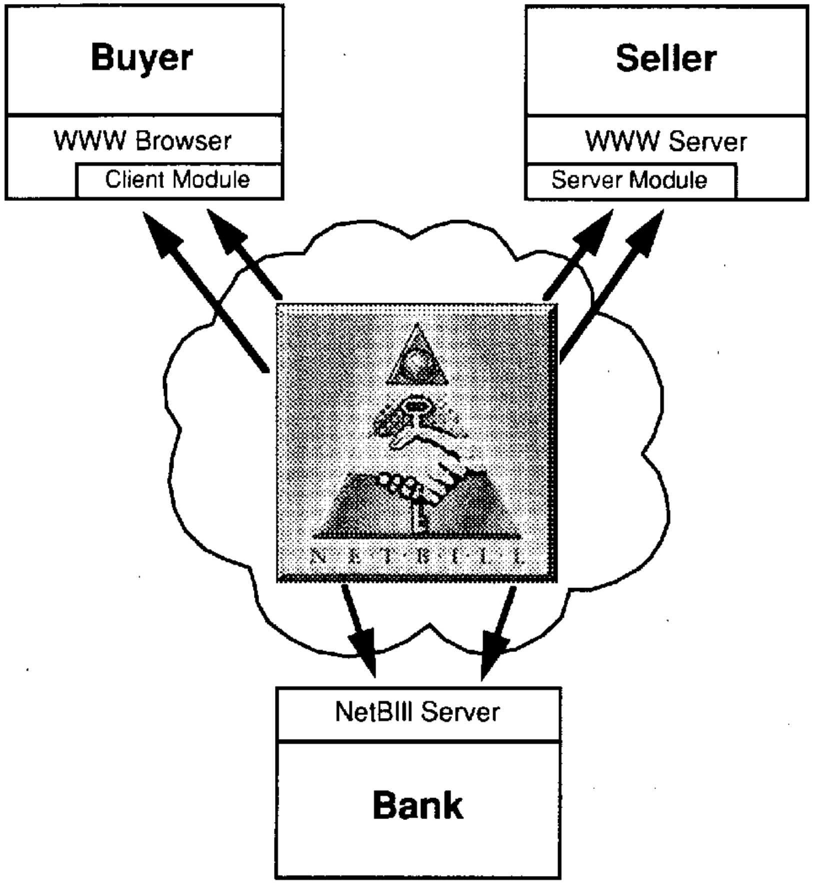
•
•
•

topic rapidly broadening and no end in sight

High-Confidence Networking - NetBill - Goals and Approach

The NetBill project at Carnegie-Mellon is developing middleware which enables microtransactions of "soft" goods, such as documents, software, or processing cycles.

Carnegie Mellon大学のNetBillプロジェクトでは、文書、ソフトウェア等の情報商品の売買を可能にするミドルウェアを開発している。



Buyer

WWW Browser

Client Module

Seller

WWW Server

Server Module

NetBill Server

Bank

- commerce middleware especially designed for microtransactions of information goods
- develop standard interfaces for interactions among a buyer's client, a seller's server, and existing banking and credit institutions
- implement plug-in modules of these interfaces for WWW client's and servers open interfaces
- implement a NetBill server that acts as a scalable, secure, low-cost, high-volume transaction clearinghouse
- supports group membership and price negotiation

一方的ではない…

High-Confidence Networking - NetBill - Team and Funding

The CMU NetBill research team receives funding from DARPA and the NSF and is working together with researches from Visa and the Mellon Bank.

NetBillプロジェクトはDARPAとNSFからの出資を受けており、Visa社とMellon Bank銀行との共同研究も行っている。

Nestor にも出てきた
BANK（何者?）

Research Team

- Marvin Sirbu, Professor
- Doug Tygar, Associate Professor
- 12 graduate students
- team from industry partner Visa (size unknown)
- team from industry partner Mellon Bank (size unknown)

Funding

- DARPA
- NSF
- industry cooperation with Visa, Mellon Bank

High-Confidence Networking - Secure Internet Routing Protocols - Goals and Aspects

BBN is researching how to integrate security into future Internet routing protocols. This R&D is funded by DARPA, which also funds BBN's development of a multigigabit next-generation router.

BBN社では将来のインターネットのプロトコルにどうセキュリティを組み込むかを研究している。この研究はDARPAにより出資されている。DARPAはBBN社のギガビット次世代ルーターの開発にも出資している。

Goals:

- researched and develop security aspects of future Internet routing protocols (Nimrod, IDRP) to make the Internet secure against denial-of-service attacks by securing all elements of the route management process
- make available publicly the security-enhanced router software resulting from the research

Aspects:

- enable routers to receive an authentic, integrity-checked software download from any source
- enable mobile hosts to authenticate themselves to routers and to establish their type-of-service authorization
- enable routers to validate the identify of any router
- enable routers to verify the integrity of routing updates
- enable routers to verify that another router is a representative of an autonomous system and that it is authorized to advertise for specific networks, subnets, etc.
- work through IETF to establish standards

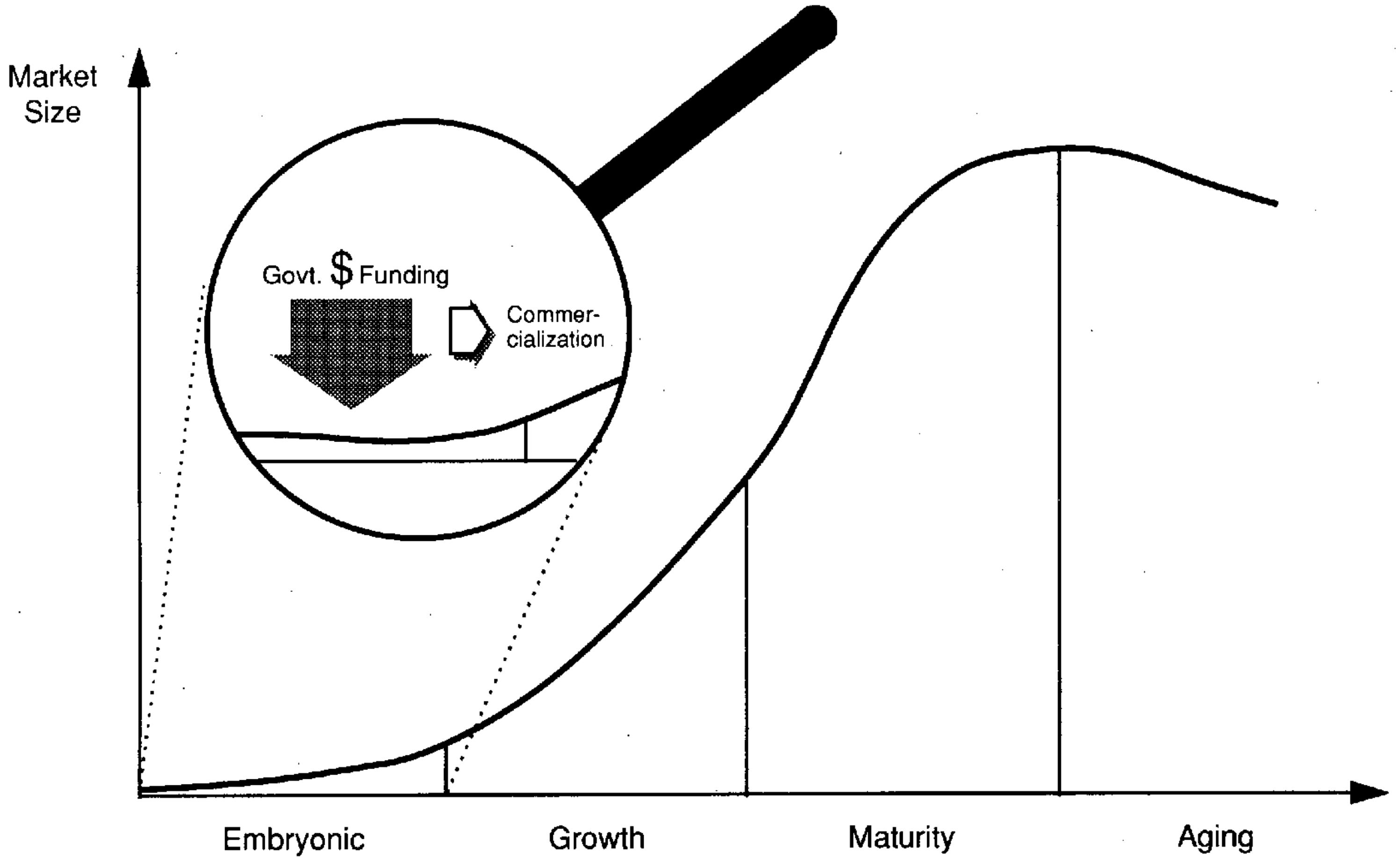
3 Technology Categories, Research Areas and Projects

3.1 Technology Categories and Funding

3.2 Research Areas and Projects

3.3 Conclusion and Lessons

Government sponsored R&D generally occurs in the earliest stage of a technology's total lifecycle.
政府出資の研究開発は、技術の全ライフサイクルの中で、最も早い段階で行われている。

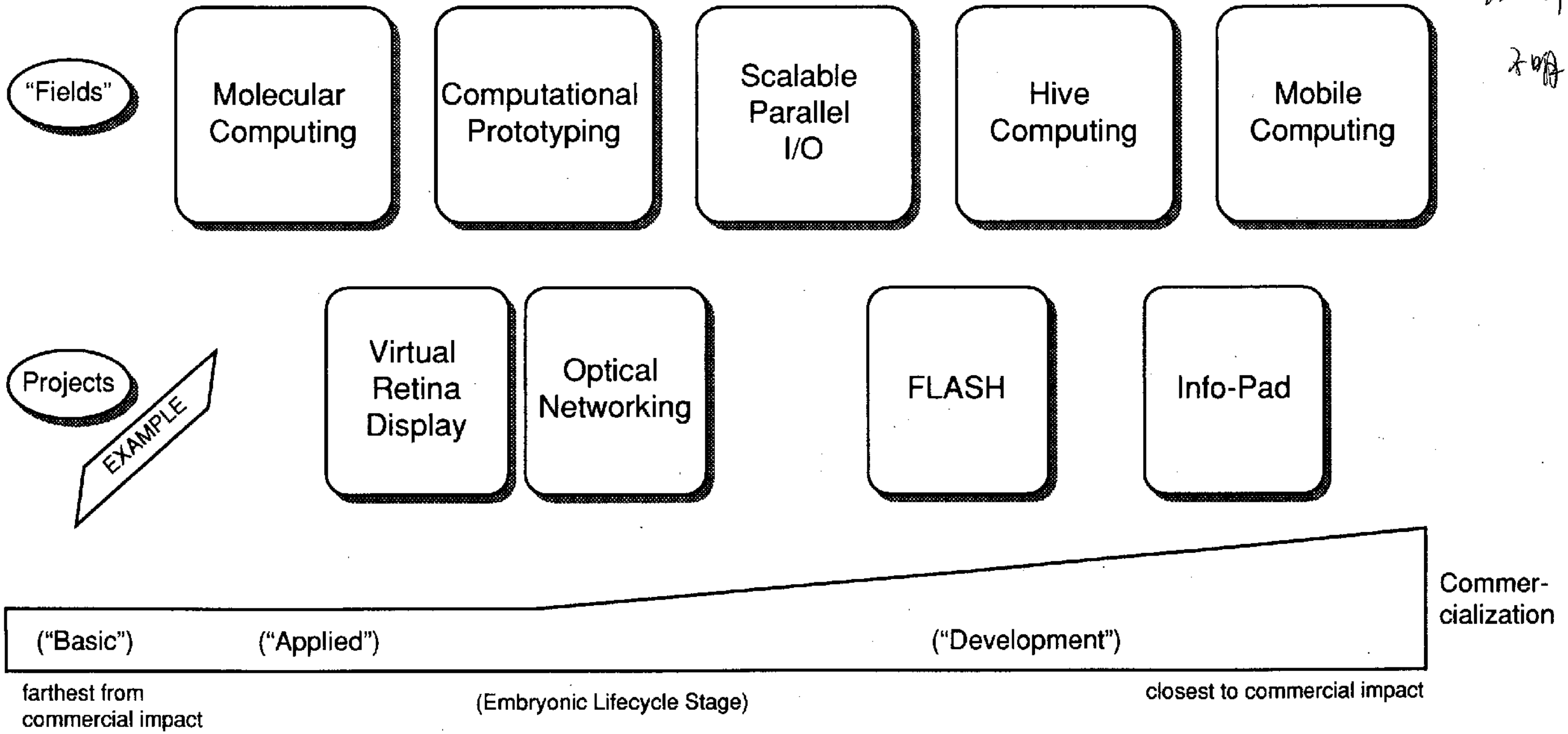


Projects and Research “Fields” on the Adoption Curve

Research “fields” and projects differ in how close they are to commercial impact but this one-dimensional view doesn’t take into account the aspect of different levels or scopes in the individual projects and in the definition of “fields”.

研究分野やプロジェクトは、そのライフサイクル中でどれだけ商業化に近いかという時間軸で分類できるが、それだけではその分野なりプロジェクトなりの範囲・広さという面が考慮されていない。

言っている事
不明



[illegible] Research [illegible]

“Scope” of Research

“Scope” of research refers to the difference in breadth, comprehensiveness, and level of aggregation of a project or field.

研究範囲の広さとは、ここではその対象技術の幅、網羅性及び総合性等を指す。

Projects differ in their scope...

- e.g. InfoPad, Berkeley is broad scope:
  - goal is to implement a complete prototype wireless computing environment
  - deals with all subissues, from terminal and basestation design to middleware and operating system to wireless protocols to applications
- vs. e.g. Graceful Degradation Techniques for Mobile Computing, Columbia is narrow Scope:
  - goal is to develop techniques, algorithms, and systems that allow mobile computing clients to achieve graceful degradation of performance when moving from areas of high-bandwidth coverage to those of low-bandwidth coverage.

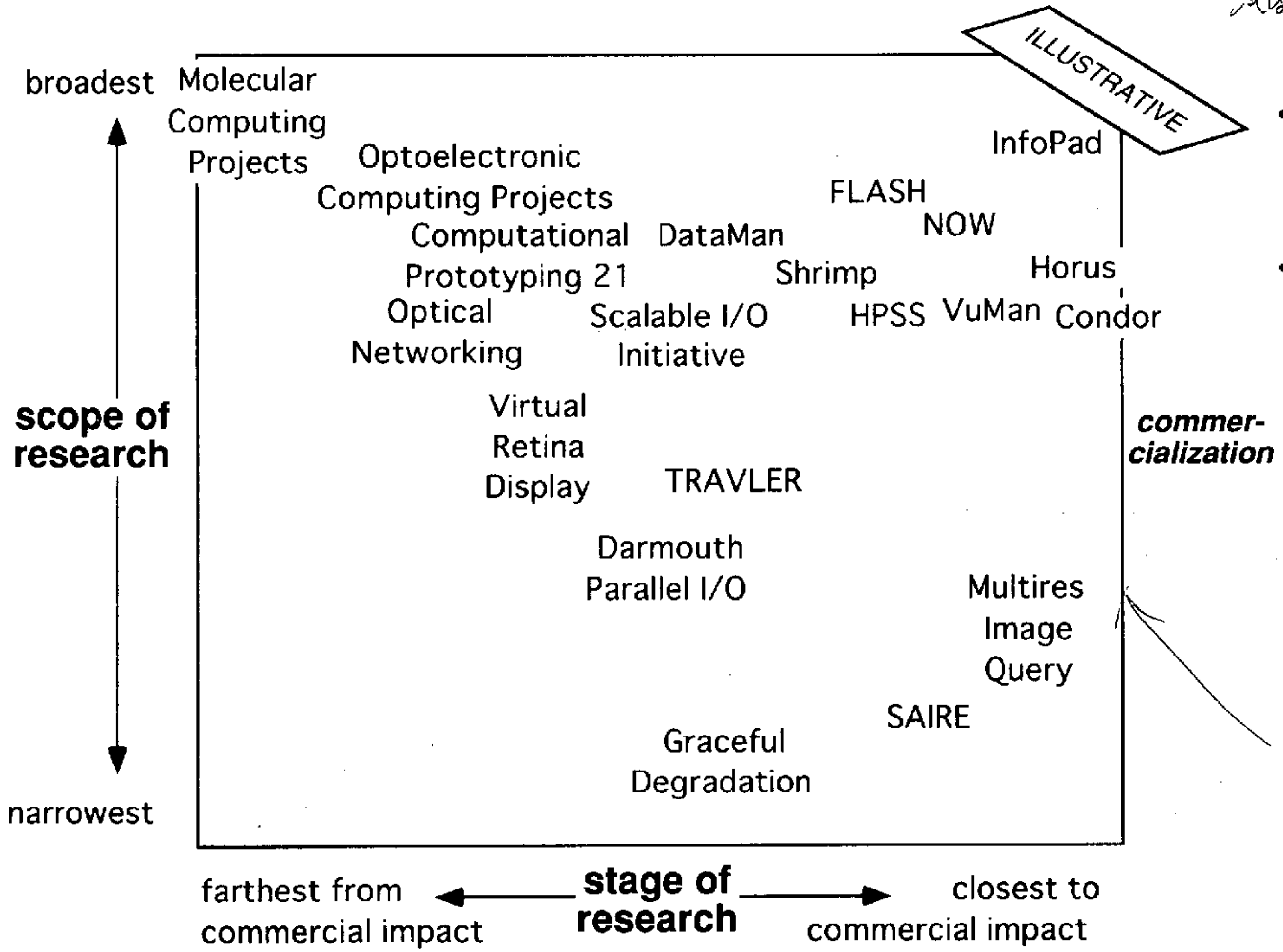
Research fields differ in their scope...

- e.g. “Hive Computing” is broad scope:
  - covers many aspects of computer systems architecture:
    - operating systems
    - memory architectures
    - local-area networking & protocols
    - languages and compilers
    - ...
- vs. e.g. “Scalable Parallel I/O” is narrower scope
  - focuses on I/O architecture issues:
    - protocols for network-attached peripherals
    - methods for parallelization of file I/O
    - ...

Map of Research Projects

We have mapped projects based on these two criteria of “stage” and “scope”.
これら時間軸的な段階と、範囲の広さの2つの尺度によって、プロジェクトがマップ上に分類できる。

これはADLの know how とみるか？…



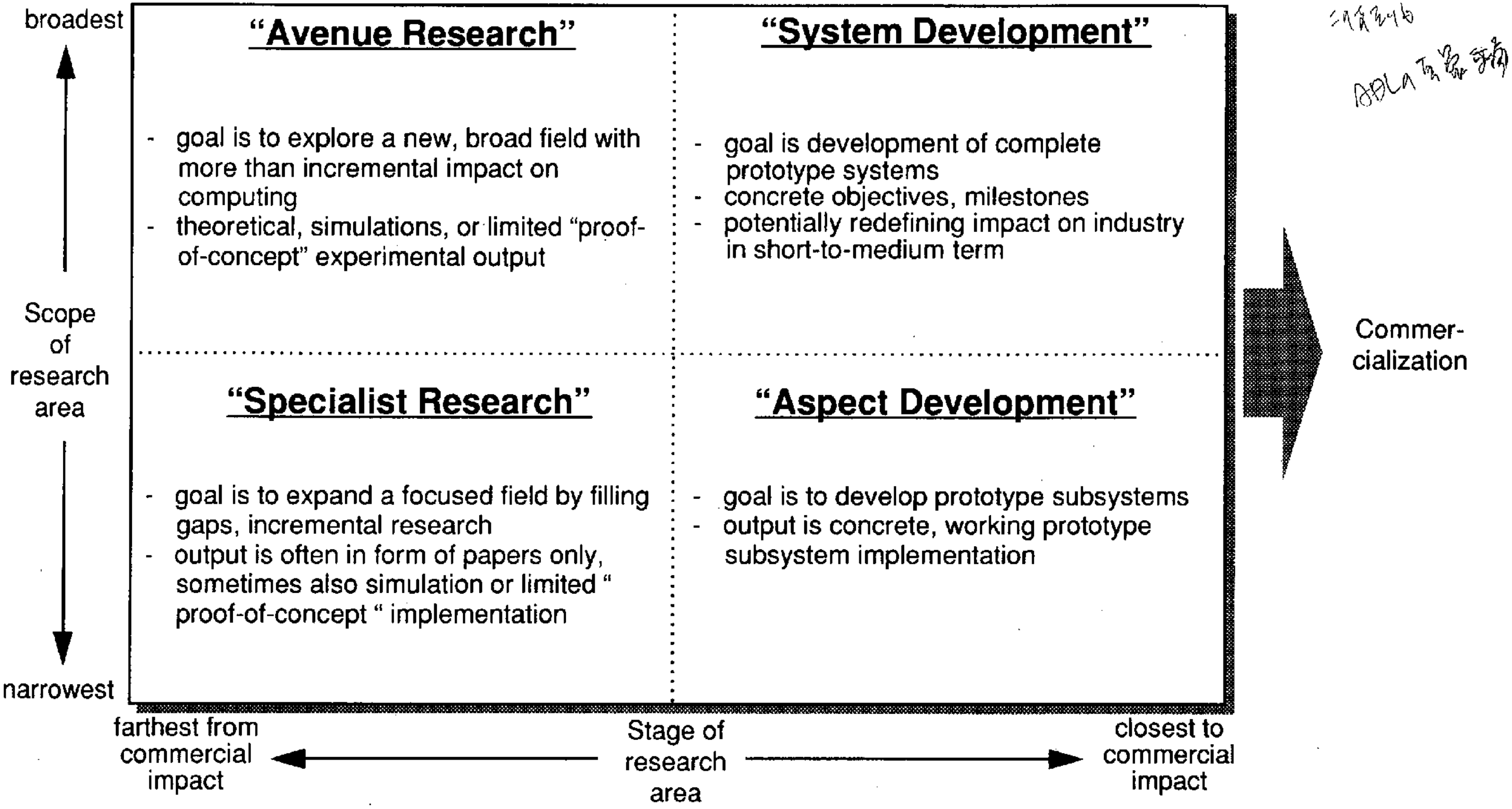
- in total, about 50 projects were judged.
- judgment was based on project goals as well as actual progress (where available), as stated in project descriptions and interviews with project leaders.

Projectの field-[illegible] [illegible]

Four Project Types (1)

While projects are scattered across the map in a continuous pattern, four generic project types with different goals, ...

プロジェクトはマップ上の色々な場所に連続的に分布するが、それらを大きく4つのタイプに分類すると、プロジェクトの目標...



"Avenue Research"

- goal is to explore a new, broad field with more than incremental impact on computing
- theoretical, simulations, or limited "proof-of-concept" experimental output

"System Development"

- goal is development of complete prototype systems
- concrete objectives, milestones
- potentially redefining impact on industry in short-to-medium term

"Specialist Research"

- goal is to expand a focused field by filling gaps, incremental research
- output is often in form of papers only, sometimes also simulation or limited " proof-of-concept " implementation

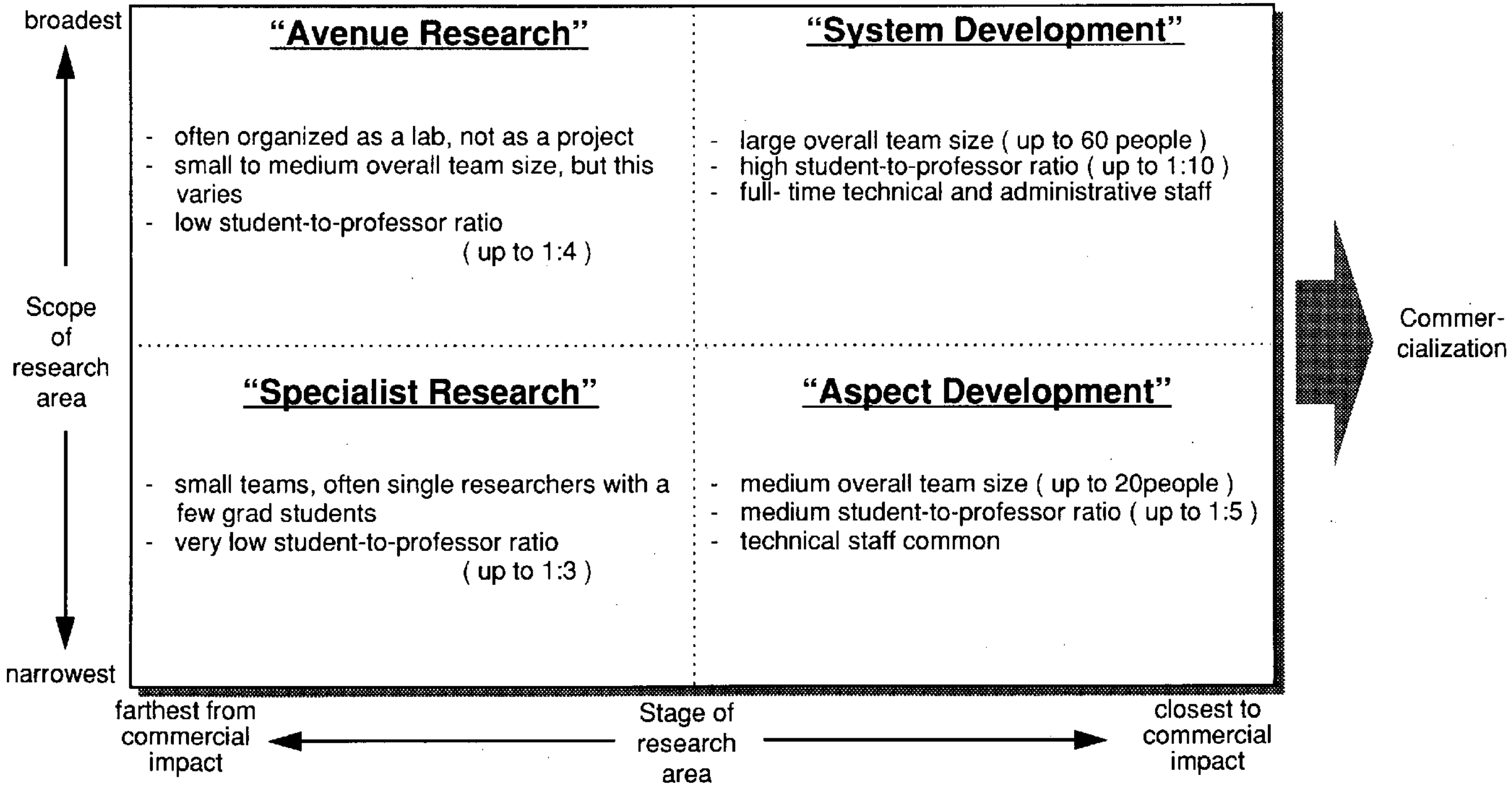
"Aspect Development"

- goal is to develop prototype subsystems
- output is concrete, working prototype subsystem implementation

二八頁より
ABLAの定義確認

Four Project Types (2)

...organization,...
...組織...



broadest

Scope of research area

narrowest

"Avenue Research"

- often organized as a lab, not as a project
- small to medium overall team size, but this varies
- low student-to-professor ratio (up to 1:4)

"System Development"

- large overall team size (up to 60 people)
- high student-to-professor ratio (up to 1:10)
- full- time technical and administrative staff

"Specialist Research"

- small teams, often single researchers with a few grad students
- very low student-to-professor ratio (up to 1:3)

"Aspect Development"

- medium overall team size (up to 20people)
- medium student-to-professor ratio (up to 1:5)
- technical staff common

farthest from commercial impact

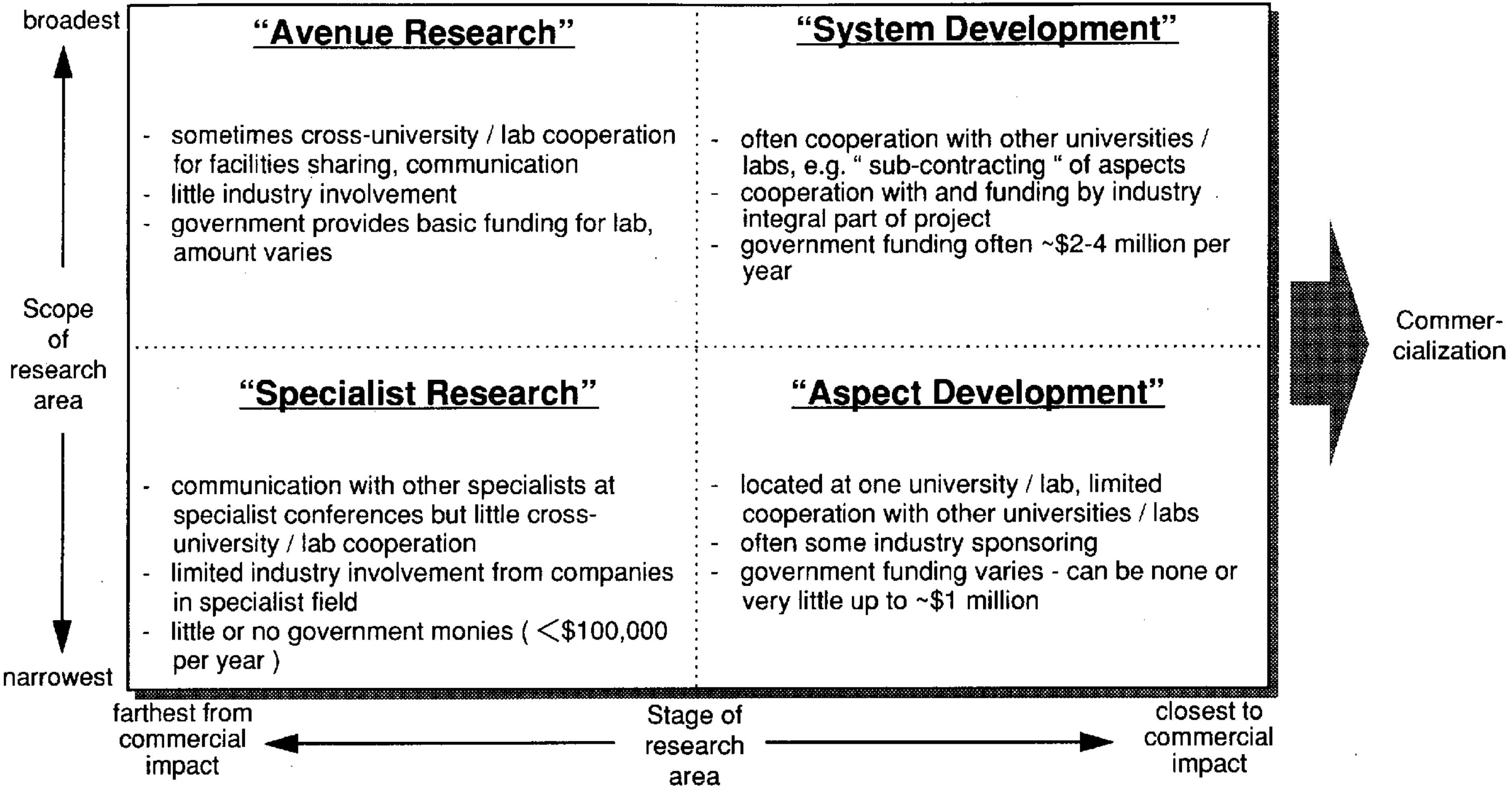
Stage of research area

closest to commercial impact

Commer-cialization

Four Project Types (3)

... industry involvement, and funding can be identified.
...産業との関係等の違う性格を持ったものに分かれる。

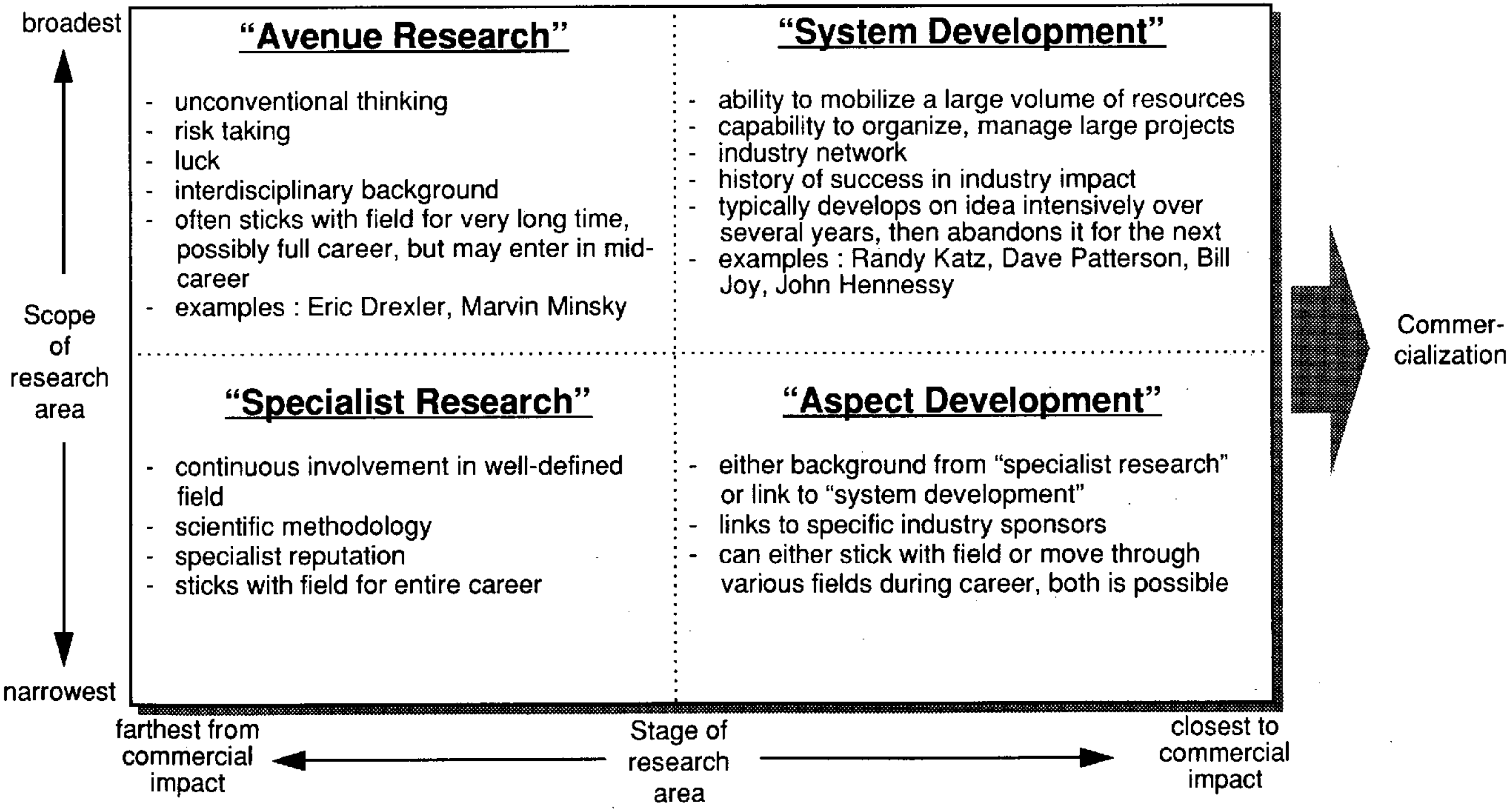


"Avenue Research" - sometimes cross-university / lab cooperation for facilities sharing, communication - little industry involvement - government provides basic funding for lab, amount varies	**"System Development"** - often cooperation with other universities / labs, e.g. " sub-contracting " of aspects - cooperation with and funding by industry integral part of project - government funding often ~$2-4 million per year
"Specialist Research" - communication with other specialists at specialist conferences but little cross-university / lab cooperation - limited industry involvement from companies in specialist field - little or no government monies (<$100,000 per year)	**"Aspect Development"** - located at one university / lab, limited cooperation with other universities / labs - often some industry sponsoring - government funding varies - can be none or very little up to ~$1 million

Necessary Project Leader Characteristics by Project Type

The type of person that can make a successful project leader differs by project type, and success in one type of project does not necessarily qualify for projects of other types.

プロジェクトリーダーとして望まれる資質は各プロジェクトのタイプによって異なりオールマイティーなプロジェクトリーダー像というものが存在するわけではない。



"Avenue Research"

- unconventional thinking
- risk taking
- luck
- interdisciplinary background
- often sticks with field for very long time, possibly full career, but may enter in mid-career
- examples : Eric Drexler, Marvin Minsky

"System Development"

- ability to mobilize a large volume of resources
- capability to organize, manage large projects
- industry network
- history of success in industry impact
- typically develops on idea intensively over several years, then abandons it for the next
- examples : Randy Katz, Dave Patterson, Bill Joy, John Hennessy

"Specialist Research"

- continuous involvement in well-defined field
- scientific methodology
- specialist reputation
- sticks with field for entire career

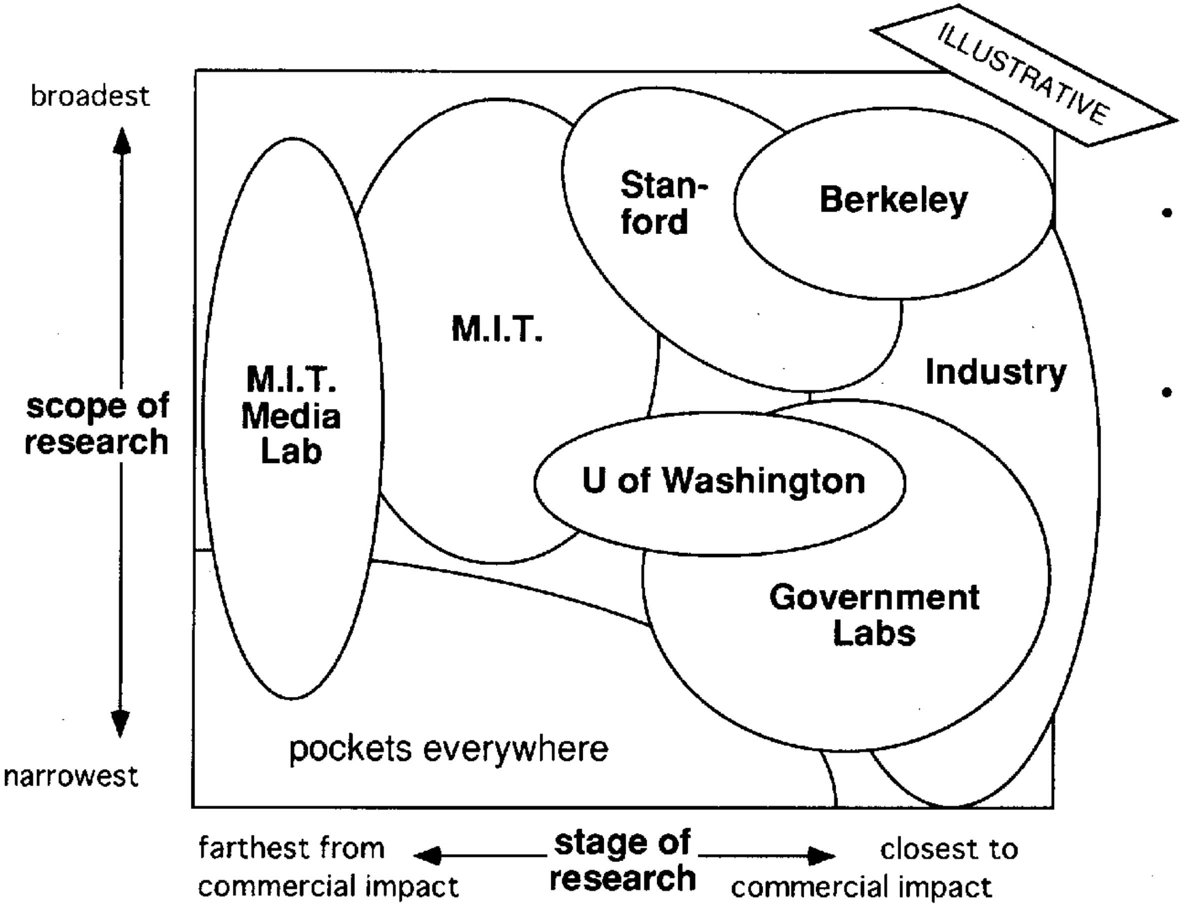
"Aspect Development"

- either background from "specialist research" or link to "system development"
- links to specific industry sponsors
- can either stick with field or move through various fields during career, both is possible

Performers by Specialization

Different performers have the majority of their research topics and projects in different parts of the map, but overall the map is well covered.

各研究機関は、傾向としてそれぞれマップ上のあるタイプの部分に配置できる。それらを合わせて国全体としては、全領域がカバーされていると見ることが出来る。

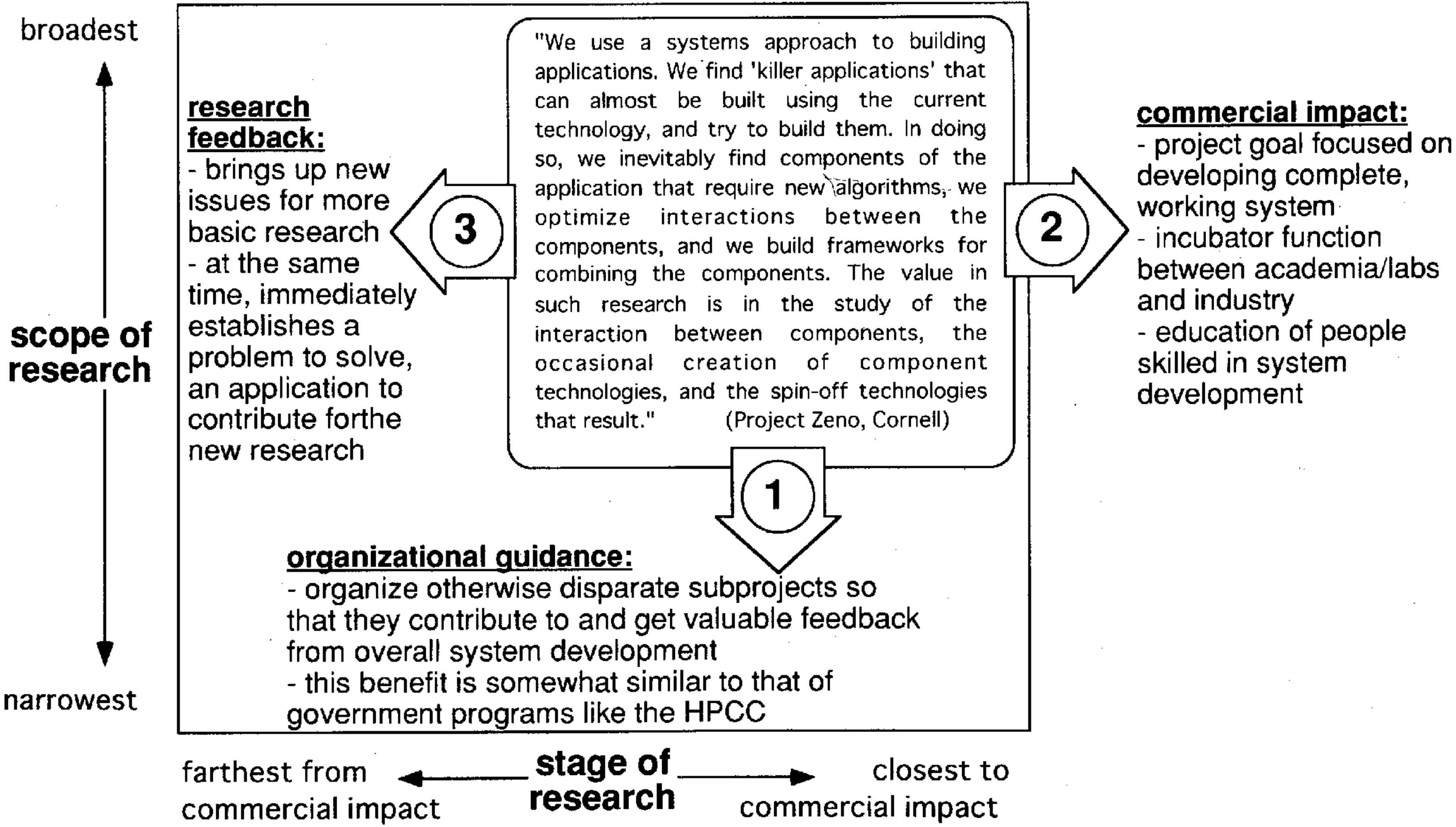


- performers shown selected from major performers to illustrate point, not to indicate merit
- position approximate and derived from a detailed analysis of major projects, survey of all research projects active at the performer, and interview feedback

Systems Development Projects as Differentiating Strength

We believe that a key strength of the U.S. system compared to Japan is the existence of and government support for "system development" projects.

ADLでは米国の研究開発の重要な強みの一つは、システム総合開発タイプのプロジェクトが活発に行われ、政府の支援も受けていることと考える。



"We use a systems approach to building applications. We find 'killer applications' that can almost be built using the current technology, and try to build them. In doing so, we inevitably find components of the application that require new algorithms, we optimize interactions between the components, and we build frameworks for combining the components. The value in such research is in the study of the interaction between components, the occasional creation of component technologies, and the spin-off technologies that result." (Project Zeno, Cornell)

research feedback:
- brings up new issues for more basic research
- at the same time, immediately establishes a problem to solve, an application to contribute forthe new research

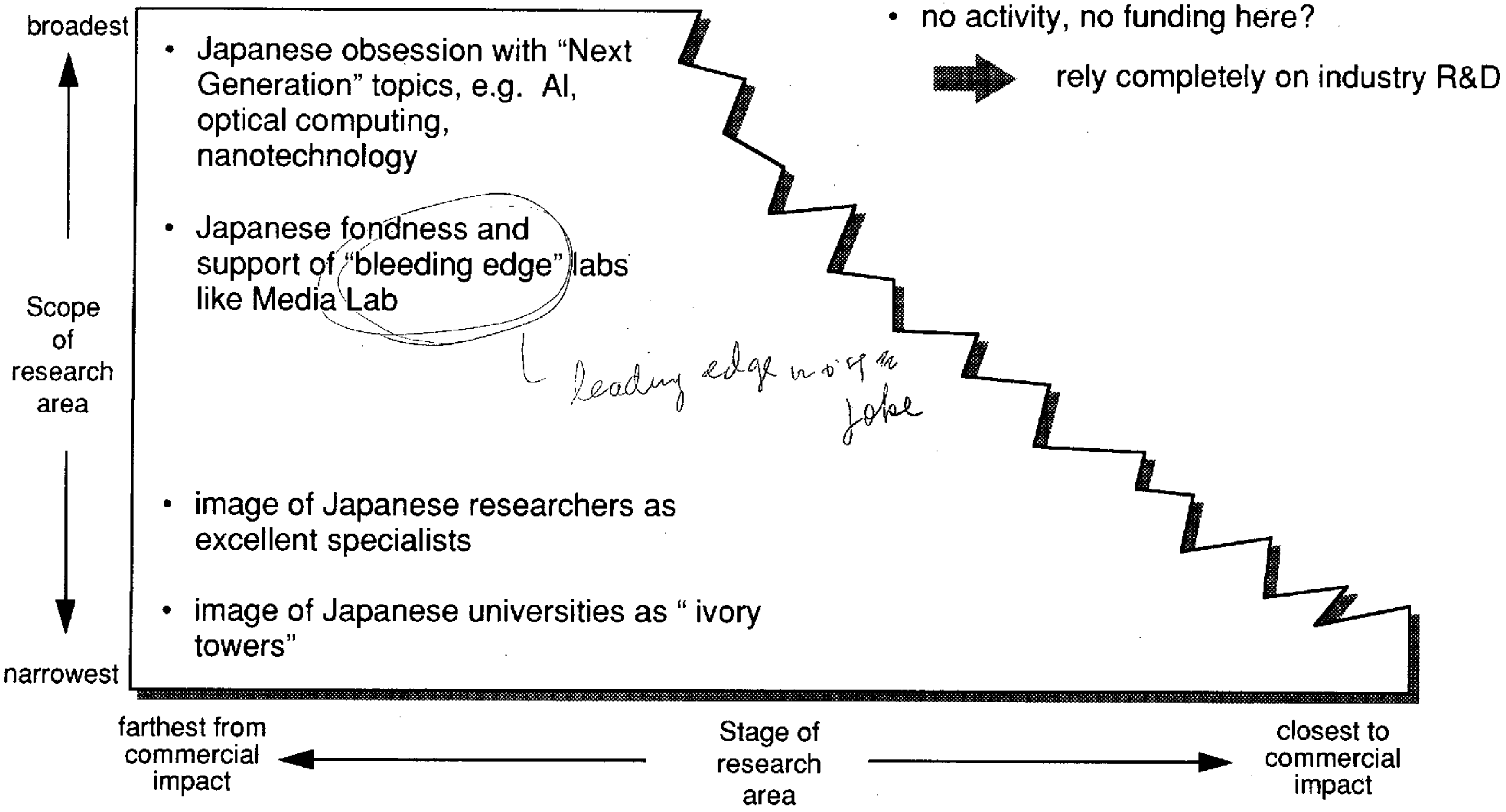
commercial impact:
- project goal focused on developing complete, working system
- incubator function between academia/labs and industry
- education of people skilled in system development

organizational guidance:
- organize otherwise disparate subprojects so that they contribute to and get valuable feedback from overall system development
- this benefit is somewhat similar to that of government programs like the HPCC

Japan's Missing Link

We also wonder whether or not in the Japanese system too much emphasis is placed on research in the left part of the map.

逆にADLの印象としては、日本ではマップの左側のタイプに重点が片寄っているように思われる。



broadest

Scope of research area

narrowest

- Japanese obsession with "Next Generation" topics, e.g. AI, optical computing, nanotechnology
- Japanese fondness and support of "bleeding edge" labs like Media Lab
- image of Japanese researchers as excellent specialists
- image of Japanese universities as " ivory towers"

leading edge [illegible] joke

- no activity, no funding here?

→ rely completely on industry R&D

farthest from commercial impact

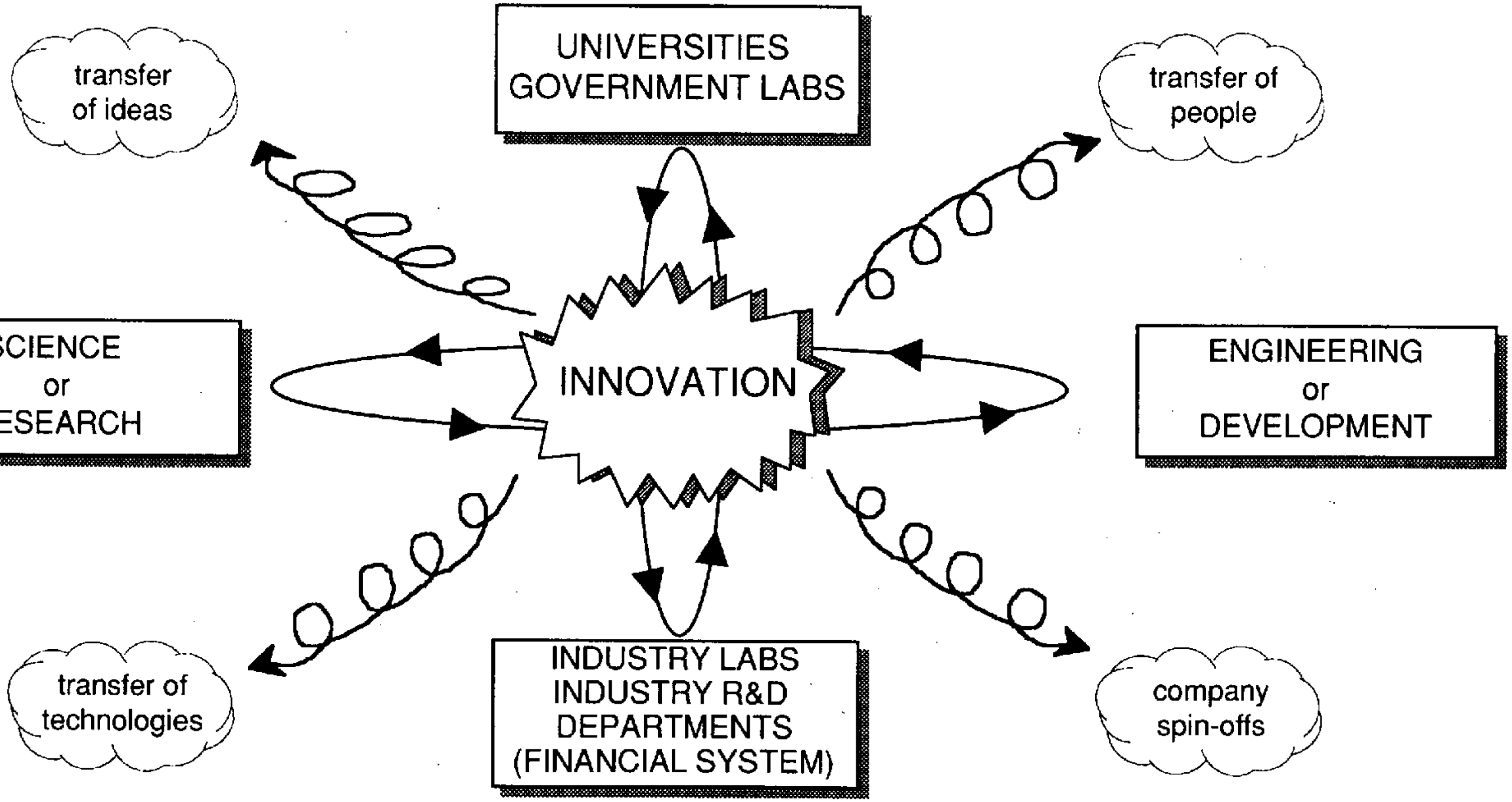
Stage of research area

closest to commercial impact

R&D as a Continuous Cycle

This seems particularly critical in view of the current understanding of R&D as a continuous feedback loop between science and engineering as well as between public and private sector...

最近の見方では、研究開発の一つの重要なプロセスは、基礎研究と開発、産と学の間に活発なやり取り、継続的な相互フィードバックが行われていることである。その点からすると、そういうやり取りを促進するシステム総合開発のタイプを持つことは重要になってくる。



transfer of ideas

UNIVERSITIES
GOVERNMENT LABS

transfer of people

SCIENCE
or
RESEARCH

INNOVATION

ENGINEERING
or
DEVELOPMENT

transfer of technologies

INDUSTRY LABS
INDUSTRY R&D
DEPARTMENTS
(FINANCIAL SYSTEM)

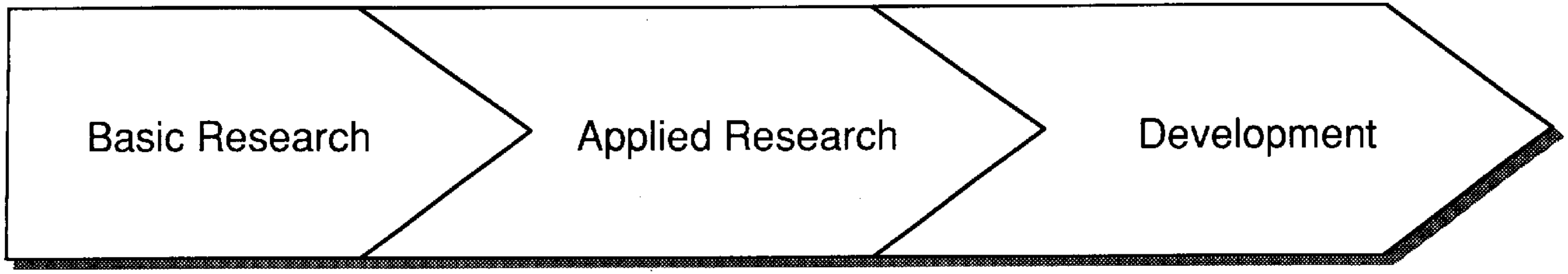
company spin-offs

➡ The better the feedback loops are running, the more innovation occurs.

➡ Government should facilitate the feedback loops.

R&D as a chain of distinct Stages

... as opposed to the overly simplistic model of R&D as a chain of linear sequential stages with distinct interfaces.
研究開発の進行を順次的な段階の進展とする見方は、現実を単純化し過ぎている。



Basic Research

Applied Research

Development

" systematic study directed toward greater knowledge or understanding of the fundamental aspects of phenomena and of observable facts without specific applications towards processes or products in mind
"

" systematic study to gain knowledge or understanding necessary to determine the means by which a recognized and specific need may be met "

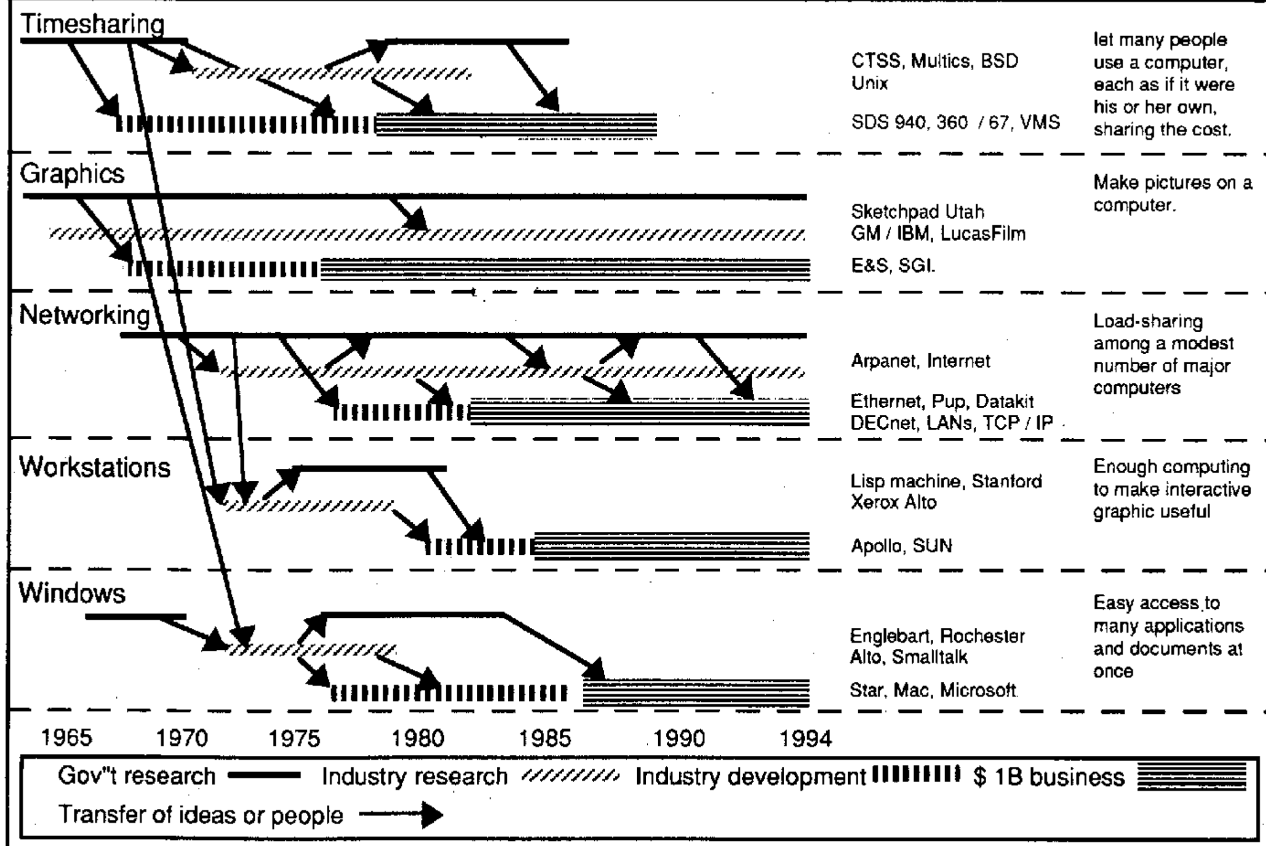
" systematic application of knowledge toward the production of useful materials, devices, and systems or methods ; including design, development, and improvement prototypes and new processes to meet specific requirements "

- Technology transfers through the different stages toward commercialization through technology push and market pull forces
- Government should allocate funding to each stage and implement incentives/instruments for transitioning between the stages

Historical Case Studies (1)

This view is backed by historical case studies, which indeed show that instead of a liner "technology transfer" from universities and government labs to industry there has been a continuous bouncing back and forth of people, ideas, and technology between the two sectors...

歴史的にもこの相互フィードバックの見方は現実の事例に合致している。学から産への一方的な技術移転だけでなく、現実には研究開発の主体が産と学の間を行ったり来たりし、人、アイデア、そして技術が行き来している。



Technology	*Timeline*	*Examples*	*Goal*	*Unanticipated Results*	*Today*
Timesharing		CTSS, Multics, BSD Unix SDS 940, 360 / 67, VMS	let many people use a computer, each as if it were his or her own, sharing the cost.	Because many people kept their work in one computer, they could easily share information. Reduced cost increased the diversity of users and applications.	Even personal computers are timeshared among multiple applications. Information sharing is ubiquitous ; shared information lives on " servers".
Graphics		Sketchpad Utah GM / IBM, LucasFilm E&S, SGI.	Make pictures on a computer.	" What you see is what you get " and hypermedia documents	Almost any image is possible. Realistic moving images made on computers are routinely seen on television and were used effectively in the deign o f the Boeing 777.
Networking		Arpanet, Internet Ethernet, Pup, Datakit DECnet, LANs, TCP / IP	Load-sharing among a modest number of major computers	Electronic mail ; widespread sharing of software and data (the original networks were wide-area) ; the interconnection of literally millions of computers	Networking has enabled worldwode communication and sharing, access to expertise, wherever it exists, and commerce at our fingertips.
Workstations		Lisp machine, Stanford Xerox Alto Apollo, SUN	Enough computing to make interactive graphic useful	Displaced most other forms of computing and terminals ; led directly to personal computers and multimedia	Millions in use for science, engineering, and finance
Windows		Englebart, Rochester Alto, Smalltalk Star, Mac, Microsoft	Easy access to many applications and documents at once	Dramatic improvements in overall ease of use ; the integration of applications (e.g., spreadsheets, word processors, and presentation graphics)	The standard way to use all computers

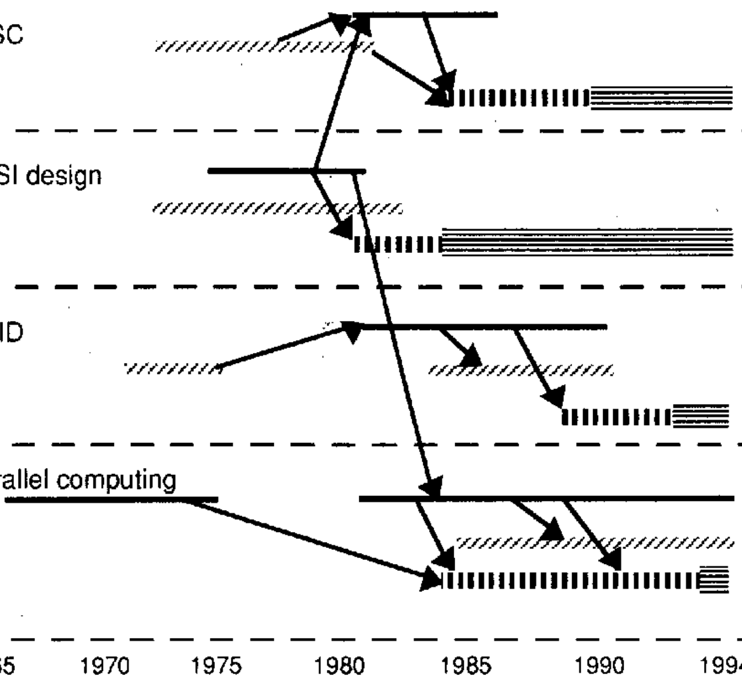
Source : National Research Council, 6 / 95

→こういったSourceが National Research Council から出てくる

Historical Case Studies (2)

... and that the original ideas and technologies had impact far beyond the original goal because of the unanticipated results that arose in the feedback loop.

その結果として元のアイデアや技術は予想もしなかった方向へと発展し、予想を超えた利益をもたらす結果にもなっている。



Technology	*Timeline*	*Examples*	*Goal*	*Unanticipated Results*	*Today*
RISC		Berkeley, Stanford IBM 801 Sun, SGI, IBM	Computer 2 to 3 times faster	Dramatic progress in the " Co -design " of hardware and software, leading to significally greater performance	Million in use ; Penetration continues to increase
VLSI design		Mead / Conway, Mosis many	New design methods to keep pace with integrated circuit technology	Easy access to " silicon foundries " ; a renaissance in computer design	Many more schools training VLSI designers ; many more companies using this technology
RAID		Berkeley Striping, Datanash Many	Faster, more reliable disk systems	RAID is more economical as well : massive data repositories ride the price / performance wave of personal computers and workstations.	Entering the mainstream for large-scale data storage ; will see widespread commercial use in digital video servers
Parallel computing		Illiac 4, C.mmp, HPC IBM RP3, Intel CM-1, Teradata, T3D	Significantly faster computing to address complex problems	Parallel deskside server system; unanticipated applications such as transaction processing, finaicial modeling, database mining, and knowledge discovery in data	Many computer manufacturers include parallel computing as a standard offering.

Gov"t research ━━ Industry research ////////// Industry development ▮▮▮▮▮▮▮▮ $ 1B business ☰
Transfer of ideas or people ──▶

Source : National Research Council, 6 / 95

3章のまとめ

この章では米国でのIT研究開発領域について見てきたが、そこから学べることを以下に挙げる。

- 研究開発領域はコンピューターシステム、コンポーネント、インテリジェントシステムとヒューマンインターフェイス、情報管理、コミュニケーションの大分類に分けられ、それぞれホットな分野がある。
- 研究開発プロジェクトは、その技術の段階と対象範囲の広さにより分類が出来、それぞれ違った性質と成功要因を持っている。
- ITの技術の発展は、科学と工学、基礎研究と応用開発、大学／研究所と産業界等の間に、人・アイデアのやり取りやフィードバックが反復的に起こるプロセスから生まれている。
- システム総合開発型のプロジェクトは、このやり取り・フィードバックのプロセスを生み出す土壌となる。
- 米国では同タイプのプロジェクト領域設定が多く、政府の出資も多く受けている。これは米国IT研究開発、ひいてはIT産業の強さの源の一つと考えられる。

まとめは、
まとまっているようで
意味不明の一面がある…

Appendices

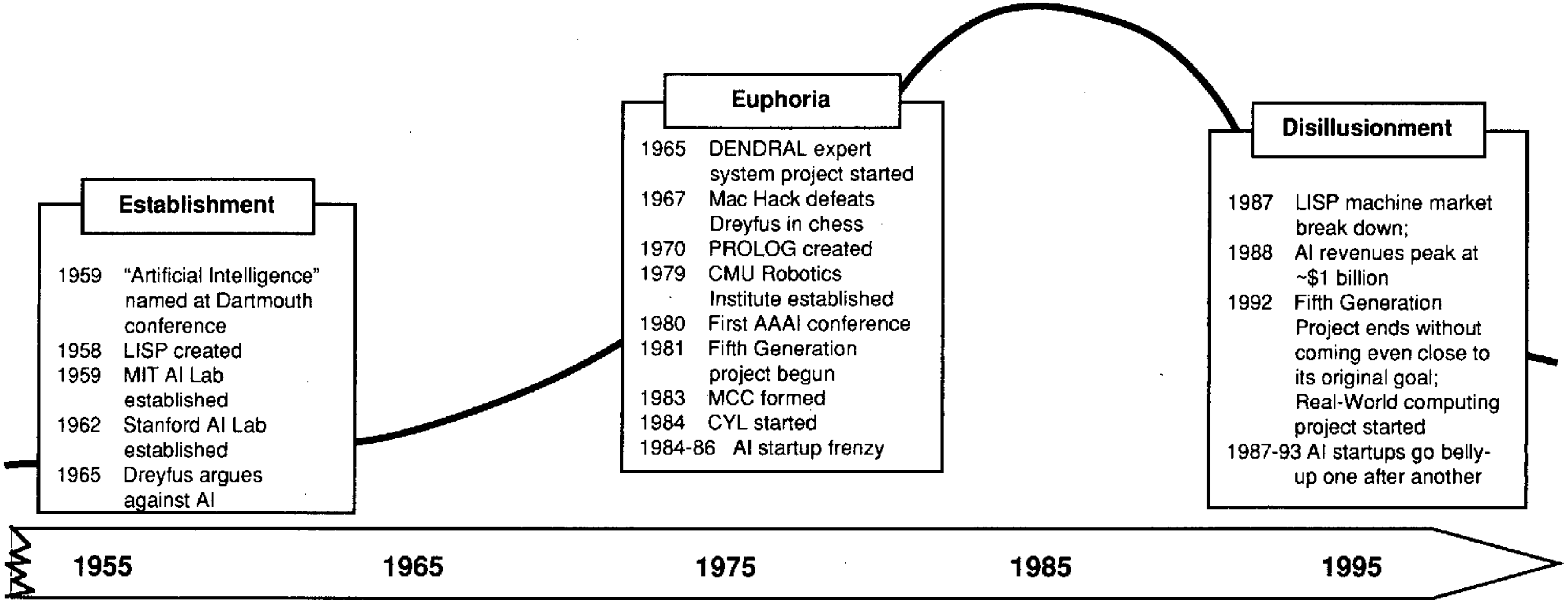
1. Hot topics in Artificial Intelligence
2. Biographies of PCAST Members
3. List of interviewees
4. List of URLs for cited projects
5. Full list of projects and participants funded by DARPAs ITO (Information Technology Office)

1. Hot topics in Artificial Intelligence

Research Trends in Artificial Intelligence - History

R&D in artificial intelligence continues to suffer from the backlash that resulted from the big disillusionment after its overhyping in the 1980s.

人工知能の研究開発は、1980年代に急速に進展した後、大きな幻滅がもたらした反動に引き続き苦しんでいる。



Establishment

1959	"Artificial Intelligence" named at Dartmouth conference
1958	LISP created
1959	MIT AI Lab established
1962	Stanford AI Lab established
1965	Dreyfus argues against AI

Euphoria

1965	DENDRAL expert system project started
1967	Mac Hack defeats Dreyfus in chess
1970	PROLOG created
1979	CMU Robotics Institute established
1980	First AAAI conference
1981	Fifth Generation project begun
1983	MCC formed
1984	CYL started
1984-86	AI startup frenzy

Disillusionment

1987	LISP machine market break down;
1988	AI revenues peak at ~$1 billion
1992	Fifth Generation Project ends without coming even close to its original goal; Real-World computing project started
1987-93	AI startups go belly-up one after another

➡ **"Calling yourself an artificial intelligence researcher is decidedly out of vogue in these mid-nineties days, at least if one has any hope of raising grant money for ongoing research." [Andrew Leonard in"Where are all the agents?", WebReview, May 3, 1996]**

Research Trends in Artificial Intelligence - Traditional AI focus

During the 1980s and early 90s, R&D in Artificial Intelligence in the US focused mainly on methods and tools for the reproduction of human reasoning and for knowledge management. Today, only a few aspects of this focus remain popular R&D topics.

1980年代から1990年代の初頭にかけて、米国での人工知能の研究開発は主に、人間の推論の再構築と知識管理のための、手法と構築ツールが中心であった。今日、この分野でよく知られた研究開発テーマはほんのわずかしか残っていない。

Symbolic Inference by Computers

Machine reasoning:

- expert systems and knowledge-based systems
- constraint logic programming

Machine learning:

- neural networks

  genetic algorithms
- case-based reasoning

Knowledge Representation for Computers

Symbolic:

- objects and scene modeling
- common sense modeling

Numeric:

- uncertainty management

  (impression or ignorance attached to hypotheses processed)

Research Trends in Artificial Intelligence - CYC Project - History

The premier project which embodies this traditional AI focus of the 80s is the CYC project. CYC (enCYClopedia) is a huge and very long term project whose goal is to understand and speak ordinary language, taking into account common sense as readily as humans do.

80年代の伝統的なAI分野に含まれるもので最初に挙げられるプロジェクトはCYCプロジェクトである。CYC（enCYClopedia）は、人間がするように常識を考慮しながら自然言語を理解し、話すことを目指した長期間の巨大プロジェクトである。

Goals:10 years $ 35 M

Microelectronics and Computer Corporation, Austin, Texas

Supported by Apple, Bellcore, DEC, DOD, Interval, Kodak and Microsoft

today:1/2 M significant assertions
tomorrow: 1M, 2M, 4M ?

huge amount of human knowledge:

facts, rules of thumb, heuristics about the objects and events in everyday life

Appropriate tools:

- knowledge base management
- representation of language
- inference engine
- interface tools

Research Trends in Artificial Intelligence - CYC Project - Results

Even though CYC already handles a large amount of human knowledge, it seems unlikely that comprehensive understanding can be reached.
CYCは既に大量の知識を取り扱っているが、広範囲な理解を行えるようにはなっていないように思える。

CYC Applications

under development

- natural language processing
- integration of heterogeneous databases
- knowledge-enhanced retrieval of data
- distributed AI
- www information retrieval

further potential

- “smart” interfaces
- intelligent character simulation
- improved machine translation
- improved speech recognition

CYC issues

- CYC seems far away from its goal of comprehensive general knowledge
- CYC works only on very simple questions or on questions which happen to fall into one of its domains of knowledge
- No objective measure of progress available
- No approximation of required knowledge available

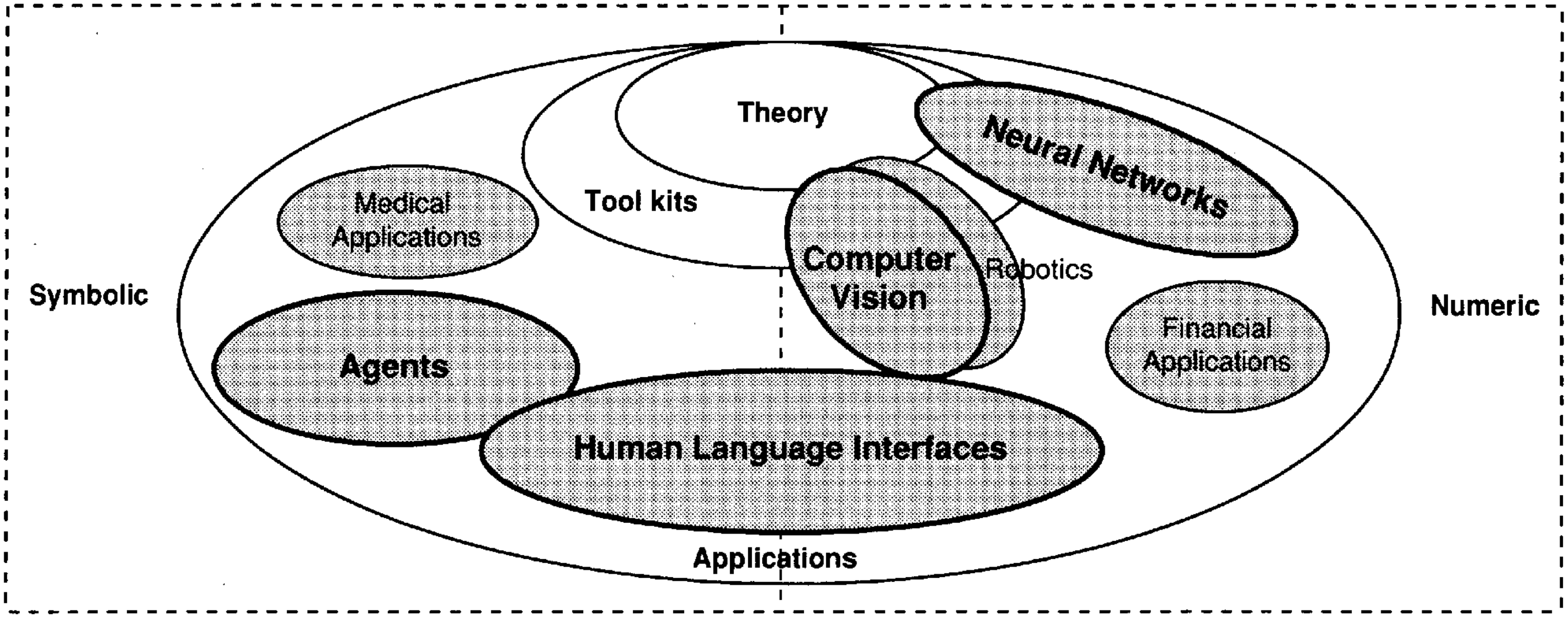
⇒ seems unlikely to achieve substantial results

AIは Themaが 大きかったらしい..)

Research Trends in Artificial Intelligence - Shifts to Applications, Numerical Approaches

In the U.S., the nineties have seen a move from theory and tool kits to applications as well as a move from symbolic to numerical approaches.

米国では90年代に入って後、理論やツールキットから応用へ、記号処理的手法から数値処理的手法への転換が見られた。



- **As funding for AI R&D has dried up, researchers have been forced to distance themselves from the "AI stigma" and to go for cover in related fields with different names if they want to raise funding.**
- **This has also led researches in Neural Networks and Fuzzy Logic to abandon the name "artificial intelligence" for the name "computational intelligence". (1994 IEEE World Congress on Computational Intelligence)**

The focus of R&D in Neural Networks has shifted from basic research to industrial applications and easy-to-apply automatic tools.

ニューラルネットワークの研究開発は基礎研究から産業界での応用や、応用しやすい自動化ツールへとシフトした。

HOT TOPICS

- simplified and automatic, easy to use tools for non-specialists
  - adaptative learning
  - structure optimization
- network input features selection
- function approximation
- hardware implementation technologies

  (on ICs, not boards)

HOT APPLICATIONS

- pattern recognition
  - classification
  - speech recognition
  - signal processing
- time series prediction
  - military
  - financial markets
- autonomous control

Feedback
学習
かかわるもの

HOT PLACES

Academic:

- Carnegie Mellon University
- MIT
- numerous other universities:

  Boston, Michigan State, Oregon, Princeton, San Diego, Southern California, Texas Industry
- ATT, BellLabs
- IBM
- numerous small companies

Research Trends in Artificial Intelligence - Neural Networks - Examples

Neural Networks are being used in a wide range of applications as easy-to-use computational tools, linked to artificial intelligence and machine learning.

ニューラルネットワークは、人工知能や学習機能と結びつき、使いやすさを狙ったツールという形で幅広く利用されている。

Carnegie Mellon University related laboratories	***MIT - CBCC*** ***(Center for Biological and Computational Learning)***	***Pacific Northwest National Laboratory (DOE)***
- Center for the Neural Basis of Cognition - Navlab: neural nets driving cars - Interactive Systems Labs: neural network - based speech recognition and multimodel interfaces	Neural nets can be used to classify, detect, encode/decode data such as face pictures. Related projects: - Face recognition and verification - video email - Example-based object detection	- Environment : artificial noses.... - Energy: food forecasting.... - National Security: voice recognition.... - Health: cardiovascular modeling.... - Science: molecular modeling....
various grants	*HPCC, NSF funded*	*DOE funded*

Computer Vision is key for intelligent machine development since it provides easily available observation tools for the real world. An important R&D trend is to merge the symbolic and numeric methods.

コンピュータビジョンは容易に利用できる実世界の観測ツールを提供するので、知的機械開発のキーとなる要素である。重要な研究開発の傾向は記号処理的手法と数値処理的手法を統合することである。

HOT TOPICS

- Symbolic Data Level;
  - objects and real world modeling
  - rule based systems
  - vision architectures
- Numeric Data Level
  - uncertainty management

    (Hypotheses quantification, data combination)

HOT APPLICATIONS

- Remote Sensing(Geographic Information Systems....)
- Robotics (Autonomous, vehicle vision related work)
- Medical Imaging (expert systems and medical diagnosis help)

Others: face recognition, handwriting recognition.....

HOT PLACES

Academic:
- Caltech
- Carnegie Mellon University
- MIT
- University of Pennsylvania
- NASA (JPL)
- most U.S. universities:

  Berkeley, Boston, Columbia, Cornell, Harvard, Florida, Illinois, Maryland, Massachusetts, San Diego, Stanford, Washington....

Industry
- numerous start-ups

Symbolic methods are used for high-level, end-of-process, computer vision to manage all the data available.

記号処理的手法は、全てのデータをうまく利用できるように、コンピュータビジョンの高水準な最終段階の処理で用いられる。

Carnegie Mellon University Digital Mapping Laboratory	*MIT Artificial Intelligence Laboratory*	*University of Pennsylvania Medical Imaging Processing Group*
Most projects led to large scale computer vision systems using both traditional and AI control structures. Research Topics: - cartographic feature extraction - photogrammetry - registration and stereo vision - multispectral imagery - knowledge-based systems	Several well-known robots have been developed at MIT. AI is used for robust agent control of autonomous robots. Example:Hannibal and Attila (autonomous planetary exploration) - 19 degrees of freedom, 60 sensory inputs, 8 microprocessors - AI perceptual processing - AI rough terrain locomotion - AI fault tolerance	This is a typical example of Image Science applied to medical reaserch Goal: Develop efficient tools for medical staff which benefit from the power of cutting-edge medical images Main applications: 3D reconstruction and intelligent analysis for diagnostic help.
various grants	*NASA, DARPA funded*	*NIH, NSF funded*

Speech Recognition and Language Understanding (written or spoken) are becoming key research points as numerous applications are developed. Still much remains to be done in the understanding of natural language.

音声認識と言語理解（書かれたものも話されたものも）は、多数の応用が開発されるにつれて、主要な研究課題になってきた。自然言語理解の分野にはまだまだ成すべきことが残っている。

HOT TOPICS

- Speech Recognition
  - improved acoustic phonetic models
  - synthetic, semantic, statistical, context constraints
  - continuous speech recognition
- Natural Language Processing
  - lexical database
  - structural grammars
  - syntactic, semantic, statistical, context constraints

HOT APPLICATIONS

- multimodel interfaces: combined text and speech information retrieval
- speech to speech translation
- dictation
- telephone interfaces
- spelling tools

HOT PLACES

Academic:
  - Carnegie Mellon University
  - MIT
  - New York University
  - Oregon Graduate Institute
  - Princeton University
  - Rutgers University
  - Stanford
  - UC Berkeley
  - UC Santa Cruz

Industry:
  - Apple
  - BBN
  - IBM
  - SRI/Corona
  - Sun Microsystems

DRAPE is not only funding academic institutes in this area, but also private corporations.
DARPAはこの分野では大学の研究所だけでなく、私企業へも出資を行なっている。

BBN	**Dragon Systems**	**IBM**	**SRI / Corona**
• developing improved robust speech recognition techniques through use of improved acoustic phonetic speech models, better adaptation techniques, domain - independent recognition, and parsimonious language models • team of ~10 people • cooperation with North - eastern University • commercialization through " HARK " products line	• is developing hierarchical analysis HMM speech recognition for PC systems • commercial impact through a wide range of speech recognition products under the " Dragon Dictate " Line	• is developing algorithms based on model combination techniques for addressing robustness problems in large - vocabulary, speaker - independent continuous speech recognition • team of 8 people • commercial impact through IBM speech recognition products, e.g. " Voice Type " • cooperates with BBN	• is developing consistency modeling techniques for various application s, such as speaker and channel mismatch and noisy speech • team of 7 people • commercial impact through SRI spin - off Corona Corp.

All DARPA funded

1つのことを、4つの機関に出している
(〜7-8人)

Agents are going through a development path similar to knowledge-based systems, shifting from comprehensive but unattainable goals to more mundane, repetitive tasks.

エージェントは、幅広いが到達できそうになかった目標から、よりありふれた繰り返しの多い処理へ目標を変えた知識ベースシステムと似た開発経過を辿っている。

HOT TOPICS

Agency:
- user needs requirements
- advanced interaction with other data or software

Intelligence:
- reasoning
- learned behavior

Mobility in the network

HOT APPLICATIONS

- information retrieval on the Net and in huge databases
- automatic on-line shopping
- system and network management
- collaboration between heterogeneous software applications
- character simulation(games, warfare)
- information management (mail, messaging)

HOT PLACES

Academic:
- Carnegie Mellon University
- MIT
- Stanford Univ.
- Univ. of Chicago
- Univ. of Maryland
- Univ. of Massachusetts
- Univ. of Michigan
- Univ. of Southern California
- Univ. of Washington

Industry:
- IBM
- Microsoft and numerous start-ups

"Agents researchers have a two-year window to make good on their hasty promises; if they fail, agent technology will suffer the same fate as its forebear AI: Grant money will dry up, academic careers will be forced to take a sharp turn and the public will be on the lookout for the next big thing" (key note speaker, PAAM'96 - Practical Applications of Intelligent Agents and Multi-Agents).

DARPA support in the field of Intelligent Agents includes very large projects, where the agents are used for specific and realistic tasks, to small projects with longer term goals.

知的エージェント分野でDARPAは、非常に大きなプロジェクト（そのプロジェクトの中でエージェントは特定の実際的な処理に用いられる）から、長期にわたる目標を持った小さなプロジェクトまでサポートしている。

Carnegie Mellon University Informedia	*MIT Intelligent Information Infrastructure Project*	*Universityof Maryland Intelligent Agent Integration*
• Multimedia digital library (video, audio, images, text....)	• general system for distributing and retrieving data on Internet	• technical issues in using intelligent agents architectures for the integration of large scale information systems
• Goal: automatic data collection and preparation for knowledge-based search and retrieval	• Goal: automated tools for managing communications flows for large organizations (email, hypermedia, other electronic media....)	• Goal: general purpose communication language for software agents
• Sponsors: - NSF, DARPA, NASA - partners include Bell, EC, Intel, Microsoft....	• first experimentation during 1992 Presidential election for automated polling and answer retrieval	• support involves Unisys, New York State, University of Maryland at College Park

All DARPA funded

2. Biographies of PCAST Members

John H. (Jack) Gibbons

John A. Young

Norman R. Augustine

Francisco J. Ayala

Murray Gell-Mann

David A. Hamburg

John P. Holdren

Diana MacArthur

Shirley M. Malcom

Sally K. Ride

Judith Rodin

Charles A. Sanders

Phillip A. Sharp

David E. Shaw

Charles M. Vest

Virginia V. Weldon

Lilian Shiao-Yen Wu

John H. (Jack) Gibbons is the Assistant to the President for Science and Technology, and Director of the Office of Science and Technology Policy. Before being appointed to his current position by the President, Dr. Gibbons was the Director of the Office of Technology Assessment, a non-partisan research arm of the United States Congress.

Dr. Gibbons is an internationally recognized scientist and an expert in energy and environmental issues. He has a deep interest and concern regarding the impacts of technology on society and their implications for public policy. He is a former Director of the Energy, Environment and Resources Center at the University of Tennessee, and was the first Director of Energy Conservation for the Federal Energy Administration. While at the Oak Ridge National Laboratory, he conducted physics research, and he directed projects on energy conservation and the environmental impact of energy production.

Born in Virginia, Dr. Gibbons graduated from Randolph-Macon College in Ashland, Virginia, and received is Ph.D. in Physics from Duke University.

John A. Young is the former President and CEO of Hewlett-Packard Co. He currently serves on the Board of Directors for Wells Fargo, SmithKline Beecham, the Chevron Corporation, Affymetrix, Shaman Pharmaceuticals, and Abiotic Systems.

Mr. Young has a distinguished record as a public servant. He served as the Chairman of the President's Commission on Industrial Competitiveness, President of the Foundation for the Malcolm Baldridge National Quality Award, and a member of the Advisory Committee on Trade Policy and Negotiations. He is also the founder and former Chairman of the private sector Council on Competitiveness. He is currently Chairman of the Board of Smart Valley, Inc.

A native of Idaho, Mr. Young received a degree in Electrical Engineering from Oregon State University and received his MBA from Stanford University. He is a member of the National Academy of Engineering.

Norman R. Augustine is the Chairman and CEO of the Martin Marietta Corporation, and serves on the Board of Directors for Phillips Petroleum and Proctor & Gamble. He has accrued more than 35 years of management experience in the private and public sectors, having formerly worked for Douglas Aircraft and LTV, as well as holding the post of Under Secretary of the Army from 1975 to 1977.

Mr. Augustine is currently serving on the Defense Policy Advisory Committee on Trade and is the Chairman of the National Security Telecommunications Advisory Committee.

Born in Denver, Mr. Augustine received both his Bachelor's and Master's degrees in aeronautical engineering from Princeton University.

Francisco J. Ayala is the Donald Bren Professor of Biological Sciences and Professor of Philosophy at the University of California, Irvine. He is President of the American Association for the Advancement of Science, and is a member of National Academy of Sciences and the American Academy of Arts and Sciences.

Dr. Ayala has been a member of advisory committees for the Environmental Protection Agency, the National Science Foundation, and the National Institutes of Health.

Dr. Ayala graduated from the University of Madrid, and subsequently earned his doctorate from Columbia University in New York. He is widely known for his scholarship on the topics of population, genetics, and evolution.

Murray Gell-Mann is a Professor of the Santa Fe Institute and Co-Chair of its Science Board. he is also the R.A. Millikan Professor Emeritus of Theoretical Physics at the California Institute of Technology. He is famous for his research in the area of elementary particle theory and was awarded the 1969 Nobel Prize in Physics.

Professor Gell-Mann has served on the former President's Science Advisory Committee, and he is currently a director of the John D. and Catherine T. MacArthur Foundation. He is a member of the National Academy of Sciences and a foreign member of the Royal Society.

Professor Gell-Mann was born in New York City, attended Yale University, and received his Ph.D. in Physics from MIT. He is the recipient of numerous honorary Doctorates in Science.

David A. Hamburg is President of Carnegie Corporation of New York. He was Professor and Chairman of the Department of Psychiatry and Reed-Hodgson Professor of Human Biology at Stanford University; then President of the Institute of Medicine, National Academy of Sciences; later, he was President, American Association for the Advancement of Science. He has also served as an advisor to the World Health Organization and the National Institute of Mental Health.

Dr. Hamburg was born in Evansville, Indiana, and received his M.D. from Indiana University.

John P. Holdren is the Class of 1935 Professor of Energy at the University of California, Berkeley, and Visiting Distinguished Scholar at the Woods Hole Research Center. He is a member of the National Academy of Sciences and Chair of its Committee on International Security and Arms Control, Chair of the Executive Committee of the Pugwash Conferences on Science and World Affairs, and a former Chairman of the Federation of American Scientists. He has written extensively on energy technology and policy, global environmental problems, and international security.

Dr. Holdren was born in Sewickley, Pennsylvania and grew up in San Meteo, California, He was trained in aeronautics and astronautics and in theoretical plasma physics at MIT and Stanford.

Diana MacArthur is Chair, CEO, and co-founder of Dynamac Corporation, a firm providing integrated environmental services, including life sciences consulting, natural resources management, and hazardous waste engineering. Previously, she served as president of a Dynamac subsidiary engaged in technology transfer, training, education, and communications in the areas of health, the environment, and safety.

Mrs. MacArthur was born in Santa Fe, New Mexico, and received her bachelor's degree from Vassar College.

Shirley M. Malcom is Head of the Directorate for Education and Human Resources Programs of the American Association for the Advancement of Science. A former high school teacher and university professor, she has been nationally recognized for her efforts to improve educational opportunities for under-represented groups and to promote broader public understanding of science and technology.

Dr. Malcom is the author of numerous publications on equity and education, and serves on a number of advisory committees relating to the evaluation of educational reform.

Dr. Malcom received her Ph.D. in ecology from The Pennsylvania State University, Master's degree in zoology from the University of California, Los Angeles, and Bachelor's degree with distinction in zoology from the University of Washington.

Mario J. Molina is the Lee and Geraldine Martin Professor of Environmental Sciences at the Massachusetts Institute of Technology. He is a member of the National Academy of Sciences and the American Association for the Advancement of Science. He has served on federal advisory committees for the National Aeronautics and Space Administration, the National Science Foundation, and the

National Institutes of Health.

Dr. Molina is a former Senior Research Scientist at the Jet Propulsion Lab. His area of expertise is chemistry of the stratosphere, and he is famous for his work on determining the sources of stratospheric ozone depletion.

Dr. Molina was an undergraduate at the Universidad Nacional Autonoma de Mexico, and he received his Ph.D. in physical chemistry from the University of California, Berkeley.

Peter H. Raven is Director of the Missouri Botanical Garden and Engelmann Professor of Botany at Washington University in St. Louis. He has served as a member of the National Science Board, is the Home Secretary of the National Academy of Sciences, and is Chairman of the Report Review Committee of the National Research Council. He is a fellow of the American Association for the Advancement of Science.

Dr. Raven is a member of the editorial board of numerous scientific publications, and has contributed more than 400 articles to professional journals. He has been awarded 14 honorary degrees in science.

Born in Shanghai, China, Dr. Raven graduated from the University of California, Berkeley, and received his Ph.D. from UCLA.

Sally K. Ride is a former astronaut and current Director of the California Space Institute at the University of California, San Diego. She is also a professor of Physics at UCSD. She is an author of three children's books and was a member of the Presidential Commission on the Space Shuttle Challenger Accident.

Dr. Ride was born in Los Angeles. She studied English and physics as an undergraduate and earned her Ph.D. in physics, all at Stanford University.

Judith Rodin is the President of the University of Pennsylvania. She serves on the editorial boards of numerous journals and she has written on the topics of obesity, appetite, aging and health behavior.

Dr. Rodin is a fellow of the Institute of Medicine, the American Academy of Arts and Sciences, the American Association for the Advancement of Science, and the American Psychological Association.

Dr. Rodin was born in Philadelphia and attended the University of Pennsylvania before receiving her Ph.D. from Columbia University.

Charles A. Sanders is Chairman and CEO of Glaxo Inc., and a member of the board of Glaxo Holdings, Merrill Lynch & Co., Reynolds Metals, and Morton International Inc. He formerly held the position of chief executive officer of the science and technology division of Squibb Corporation. Previously, he was general director of Massachusetts General Hospital and professor of medicine at Harvard Medical School.

Dr. Sanders is a member of the Institute of Medicine of the National Academy complex, and serves as Chairman of Project HOPE and the Commonwealth Fund.

Dr. Sanders is a native of Dallas and a graduate of the Southwestern Medical

College of the University of Texas.

Phillip A. Sharp is Professor of Biology, Head of the Department of Biology, and former Director of the Center for Cancer Research at the Massachusetts Institute of Technology. He is a co-founder, and member of the Board of Directors of Biogen, Inc.

Dr. Sharp was a co-recipient of the 1993 Nobel Prize in Physiology or Medicine for his research on gene structure. He is a member of the National Academy of Sciences and Institute of Medicine, and a fellow of the American Association for the Advancement of Science.

Dr. Sharp was born in Falmouth, Kentucky, received his BA from Union College, Kentucky, and earned his Ph.D. in Chemistry from the University of Illinois, Urbana.

David E. Shaw is the CEO of D.E. Shaw & Co., a group of technology-oriented financial firms. The author of numerous publications on science, technology, and public policy, Dr. Shaw is a member of the Board of Governors of the New York Academy of Sciences, and formerly served on the faculty of the Computer Science Department at Columbia University and as a vice president at Morgan Stanley & Co.

Dr. Shaw graduated from the University of California, San Diego. He received his Ph.D. from Stanford University, where his research centered on massively parallel supercomputing.

Charles M. Vest is President of the Massachusetts Institute of Technology, and a Professor of Mechanical Engineering. He is a former Provost, Vice President for Academic Affairs, and Dean of the College of Engineering at the University of Michigan, Ann Arbor. His research interests are in the areas of heat transfer, fluid mechanics and optics.

Dr. Vest serves on the Board of Directors for IBM and the E.I. du Pont de Nemours & Company. He is a trustee of the Boston Museum of Science, Wellesley College, WGBH Educational Foundation, and Woods Hole Oceanographic Institution. He is a member of the National Academy of Engineering, and a fellow of the American Academy of Arts and Sciences, and of the American Association for the Advancement of Science.

Born in Morgantown, West Virginia, Dr. Vest attended the University of West Virginia before receiving his Ph.D. in mechanical engineering from the University of Michigan.

Virginia V. Weldon is Senior Vice President for Public Policy for the Monsanto Company. She is a former professor of pediatrics, Deputy Vice Chancellor for Medical Affairs, and Vice President of the Medical Center at the Washington University School of Medicine, St. Louis. She previously served as Chair of the Assembly of the Association of American Medical Colleges and as a member of the Board of Directors of Southwestern Bell. She currently is a member of the Board of Directors for G.D. Searle & Co., The Nutrasweet Corporation, and the General

American Life Insurance Company.

Dr. Weldon is a member of the Institute of Medicine of the National Academy of Sciences, the Society for Pediatric Research and the American Pediatric Association. her research interests are in the area of growth disorders and hormone secretion in children.

Dr. Weldon was born in Toronto, Canada, and is a U.S. citizen. She received her bachelor's degree from Smith College and her M.D. from the State University of New York, Buffalo.

Lilian Shiao-Yen Wu is a member of the Research staff at IBM's Thomas J. Watson Research Center. She is also a Director of the International Institute of Forecasters, and is currently serving on the National Research Council's Committee on Women in Science and Technology.

Dr. Wu's accomplishments include the development of innovative mathematical models and statistical methods for business forecasting and planning, and the implementation of those methods in business practice.

Dr. Wu was born in Beijing, China. She is a graduate of the University of Maryland at College Park, and received her Ph.D. in Applied Mathematics from Cornell University.

3. List of interviewees

Project Advisor

C. Gordon Bell, Microsoft Research Group. Formerly Vice President of R&D at DEC, Professor of Computer Science and Electrical Engineering at Carnegie-Mellon University, Assistant Director of the National Science Foundation's Computing Directorate. Led the National Research and Education Network (NREN) panel that became the NII/GII and was an author of the first High Performance Computer and Communications Initiative. Awards include the IEEE Von Neumann Medal and the National Medal of Technology. His full biography is at

http://131.107.1.182:80/research/barc/gbell/ .

Main Project Interviewees

Joseph Bordogna, Head of the Directorate of Engineering at the National Science Foundation. Biography at

http://www.nsf.gov:80/eng/joebio.htm . Face-to-face interview.

Melvyn Ciment, Deputy Assistant Director of the Computer and Information Sciences and Engineering Directorate at the National Sicence Foundation. Biography at

http://www.cise.nsf.gov/oad/mciment.html . Face-to-face interview.

Robert L. Constable, Professor of Computer Science and Chair of Department of Computer Science at Cornell University. Biography at

http://www.cs.cornell.edu/Info/Department/Annual95/Faculty/Constable.html . Phone interview.

William J. Feiereisen, Director of the National Aeronautics and Space Administration HPCC Program at Ames Research Center. Phone interview.

Lance A. Glasser, Director of the Electronics Technology Office of the Defense Advanced Projects Research Agency. Biography at

http://eto.sysplan.com/ETO/People/glasser.html . Phone interview.

Dan Hitchcock, Acting Division Director of the Division of Mathematical, Information, and Computational Sciences and Manager of the HPCC Program at the Department of Energy. Biography at

http://www.er.doe.gov/production/octr/mics/hitchcoc.html . Face-to-face interview.

Michael Irish, former member of and now consultant to the Economic Strategy Institute. Face-to-face interview.

Randy H. Katz, Professor of Computer Science and Chair of the Electrical Engineering and Computer Science Department at the University of California at Berkeley. Biography at

http://HTTP.CS.Berkeley.EDU/~randy/ . Face-to-face interview.

Duncan H. Lawrie, Professor of Computer Science and Head of the Department of Computer Science at the University of Illinois. Biography at

http://www.cs.uiuc.edu/CS_INFO_SERVER/DEPT_INFO/CS_FACULTY/FAC_HTMLS/lawrie.html . Face-to-face interview.

Edward D. Lazowska, Professor of Computer Science and Chair of the Department of Computer Science and Engineering at the University of Washington. Biography at

http://www.cs.washington.edu/homes/lazowska/cra/lazowska.html . Face-to-face interview.

William F. Miller, Professor of Computer Science and Leader of the Stanford Computer Industry Project at Stanford University. Biography at

http://gsb-www.stanford.edu:80/scip/miller-bio.html . Face-to-face interview.

Robert W. Taylor, Director of Digital Equipment Corporation's Systems Research Center. Biography at

http://www.research.digital.com/SRC/staff/taylor/bio.html . Face-to-face interview.

John C. Toole, Director of the National Coordination Office for the High Performance Computing and Communications Initiative and Chair of the High Performance Computing, Communications, and Information Technology Subcommittee of the Committee on Information and Communications of the National Science and Technology Council. Biography at

http://www.hpcc.gov/staff/toole.bio.html . Face-to-face interview.

Robert M. White, Professor of Computer Science and Head of Electrical and Computer Engineering Department at Carnegie-Mellon University. Biography at

http://www.ece.cmu.edu/afs/ece/usr/white/home.html . Face-to-face interview.

In addition to these high level interviews we have talked on the phone or had email exchanges with numerous people involved in the research projects we were examining or associated with technology transfer offices at both universities and government laboratories.

4. List of URLs for cited projects

The following are the URLs for all research projects cited, together with the URLs for other key organisations involved in the US R&D system.

High-level coordinating bodies

OMB (Office of Management & Budget)

http://www.whitehouse.gov/WH/EOP/OMB/html/ombhome.html

OSTP (Office of Science and Technology Policy)

http://www.whitehouse.gov/WH/EOP/OSTP/html/OSTP_Home.html

NSTC (National Science and Technology Council)

http://www.whitehouse.gov/WH/EOP/OSTP/NSTC/html/NSTC_Home.html

PCAST (Presidential Committee of Advisors on Science and Technology)

http://www.whitehouse.gov:80/White_House/EOP/OSTP/NSTC/html/pcast.html

NCO (National Coordination Office for HPCC)

http://www.hpcc.gov/

NCO Gopher gopher://gopher.hpcc.gov:70/1

CIC (Committee on Information and Communications)

http://www.hpcc.gov/cic/index.html

Funding Agencies

Independent Federal Agencies and Commissions

http://www.whitehouse.gov/WH/Independent_Agencies/html/independent_links.html

NSF (National Science Foundation) http://stis.nsf.gov/

NSF CISE (Computer and Information Science and Engineering)

http://www.cise.nsf.gov/

DARPA (Defense Advanced Research Projects Agency)

http://www.arpa.mil/

DARPA ITO Research Programs

http://www.ito.darpa.mil/ResearchAreas.html

DARPA ETO R&D Areas

http://eto.sysplan.com/ETO/RandD.html

Electronics Subcommittee Navigator @ DARPA

http://esc.sysplan.com/ESC/Navigator/FrontPage.html

DoE (Department of Energy) http://www.doe.gov/

NASA (National Aeronautics and Space Administration)	http://www.nasa.gov/
NSA (National Security Agency)	http://www.nsa.gov:8080/
NIST (National Institute of Standards and Technology)	http://www.nist.gov/
NIH (National Institutes of Health)	http://www.nih.gov/

R&D Performers

CRA Database of CS/CE Departments	http://cra.org/cgi-bin/SearchDBF.pl?grad.dbf+sgrad.tpl+rgrad.tpl
U.S. Government Laboratories	http://info.er.usgs.gov/network/gov.html
CRA Database of Industrial Research Labs	http://cra.org/cgi-bin/SearchDBF.pl?ind.dbf+sind.tpl+rind.tpl

Research Projects

UC Berkeley NOW Project	http://now.cs.berkeley.edu/
Stanford FLASH Project	http://www-flash.stanford.edu/
Princeton Shrimp Project	http://www.cs.princeton.edu/shrimp/
Wisconsin Wind Tunnel Project	http://www.cs.wisc.edu:80/˜wwt/
Wisconsin Condor Project	http://www.cs.wisc.edu/condor/
UC Berkeley InfoPad Project	http://infopad.eecs.berkeley.edu/
Rutgers DATAMAN Project	http://athos.rutgers.edu:80/dataman/
Purdue Mobile Computing Research	http://www.cs.purdue.edu/research/cse/mobile/
Columbia Mobile Computing Lab	http://www.mcl.cs.columbia.edu/
NSL HPSS Project	http://www.llnl.gov/liv_comp/nsl/hpss/hpss.html
Scalable I/O Initiative	http://www.ccsf.caltech.edu/SIO/SIO.html
Dartmouth Parallel I/O Research	http://www.cs.dartmouth.edu/research/pario.html
Stanford Computational Prototyping of Semiconductors Project	http://snf.stanford.edu/ComputationalPrototyping/
MIT Computer-Aided Prototyping of Advanced Microsystems Technology Project	http://www-mtl.mit.edu/CAPAM/CAPAM.html
Foresight Institute	http://www.foresight.org/
Xerox PARC Nanotechnology	http://nano.xerox.com/nano
Rice Center for Nanoscale Science and Technology	http://cnst.rice.edu/cnst.html

National Nanofabrication Users Network	http://snf.stanford.edu/NNUN/
Carnegie-Mellon Speech Research	http://www.ri.cmu.edu/speech/
Carnegie-Mellon Interactive Systems Lab	http://www.is.cs.cmu.edu:80/ISL.html
UC Santa Cruz Perceptual Science Lab	http://mambo.ucsc.edu/
Carnegie-Mellon VuMan Project	http://www.cs.cmu.edu/afs/cs.cmu.edu/project/vuman/www/home.html
Washington Virtual Retinal Display Project	http://www.hitl.washington.edu/projects/vrd/
Columbia Computer Graphics and User Interfaces Lab	http://www.cs.columbia.edu:80/graphics/
MIT Remembrance Agent Project	http://rhodes.www.media.mit.edu/people/rhodes/remembrance.html
UC Berkeley Digital Library Project	http://elib.cs.berkeley.edu/
Washington Fast Multiresolution Image Querying Project	http://www.cs.washington.edu/research/projects/grail2/www/Projects/query.html
Optivision All-Optical Gigabit LAN Project	http://www.optivision.com/nsds/hatc.html
TBONE Testbed Project	http://www.optivision.com/nsds/tbone.html
Princeton 100 Gb/s Packet-Switched Multihop Transparent Optical Networks Project	http://www.ito.darpa.mil/Summaries95/B281--Princeton.html
Carnegie-Mellon NetBill Project	http://www.ini.cmu.edu/netbill/
BBN Internet Routing Infrastructure Security Project	http://www.ito.darpa.mil/Summaries95/D332--BBN.html

5. Full list of projects and participants funded by DARPAs ITO (Information Technology Office)

The following is a full list of all companies receiving grants from DARPA's ITO in 1995, together with the names of each of the projects funded. More information can be obtained directly from the ITO, at:

http://www.ito.darpa.mil/

The Aerospace Corporation

- Decentralized Network Management

Applied Parallel Research, Inc.

- Development of An Interactive Restructurer

AT&T Bell Laboratories

- Intelligent Node

Bolt Beraneck and Newman Inc.

- Gigabit Satellite Network
- Interactive Spoken Language Understanding Systems
- Internet Routing Infrastructure Security
- Language Modeling for Text Understanding
- Multigigabit Router
- Nimrod: A Scalable Internet Routing and Addressing Architecture
- Robust Continuous Speech Recognition
- Support for Distributed Real-Time Multimedia Applications in Mobile Wireless Networks

Bell Atlantic Federal Systems

- SONET / ATM testbed

Bell Communications Research (Bellcore)

- Booster Protocols for Distributed Computing Systems

Boeing Defense & Space Group

- Software Technology for Adaptable, Reliable Systems

Boeing Information and Support Services

- Industrial Strength Sparse Matrix Library

Computational Logic, Inc.

- Formal Computational Logic
- Software Development Technologies for Reactive, Real-Time, and Hybrid Systems

Convex Computer Corporation

- Automatic Algorithm Recognition in Scientific Applications

Corporation for National Research Initiatives (CNRI)

- Digital Object Infrastructure
- Research on Gigabit Networks

- Research on Linking Electronic Libraries of Scientific and Technical Information

Cray Research

- TFLOPS Scalable HPC System

Dragon Systems, Inc.

- Research in Large Vocabulary Continuous Speech Recognition

Enterprise Computing Institute

- Performance Engineering

Environmental Research Institute of Michigan

- Touchstone HPC and Advanced SAR Processing

Financial Services Technology Consortium (FSTC)

- Electronic Check Project

FTL Systems

- Parallel VHDL Simulation

Georgia Tech Research Corporation

- COBS - High Performance Objects
- Replication in Distributed Systems

Honeywell Technology Center

- A Shared HCI Environment
- Adaptive Resource Allocation (ARA)
- Development Assistance for Real-Time System Software (DARTSS)
- Domain-Specific Software Architectures for Guidance, Navigation and Control
- Embedded Touchstone HPC
- Network Services for Real-Time Control
- Real-Time HPC Benchmarks

Hughes Aircraft Company

- Embedded HPC For Missiles and Avionics
- Embedded HPC SW Technology

IBM Corporation

- Applying Statistical Methods to Machine Translation
- Automatic Methods for Building Language Understanding Systems
- Microkernel-Based Real-Time Systems
- Parallelization of Commercial Engineering Software
- Robust Context Dependent Models and Features for Continuous Speech Recognition

Institute for Defense Analysis

- Computing Safeguards
- Quantifying the Costs and Benefits of the STARS Megaprogramming Technologies

Integrated Sensors, Inc.

- Real-Time Development Environment for Embedded HPC Systems

Intel Corporation, Supercomputer Systems Division

- A Cooperative Agreement for Research in Concurrent Computer Systems (Touchstone)
- Development of Real-Time, Secure Operating System for Scalable, Parallel, Heterogeneous Processing System
- Igniting the Proliferation of ARPA-Sponsored SHPC Systems (Renaissance)
- MPI Validation Suite
- TriStar Computing Systems Technology.

Intermetrics, Inc.

- ProtoTech Phase Two

Kestrel Institute

- A Prototyping System for Parallel and Distributed Applications

Litton Guidance & Control Systems

- Demo of EMPP as Universal Beamformer
- Embeddable Massively Parallel Processor
- Fault Tolerant Massively Parallel Processor

Lockheed Martin

- Embedded High Performance Scalable Computing System
- Scalable High Performance Embedded Signal Processor For UUV Applications
- Secure Heterogeneous Application Runtime Environment for High Performance Scalable Computing Systems (SHARE*HPSC)
- Space-Time Adaptive Processor
- TDigital Micro-Architectures VHDL Models for High Performance Scalable Computing Systems

Loral Defense Systems

- Domain-Specific Software Architecture: The Avionics Development and Application Generation Environment (DSSA-ADAGE) Project
- Software Technology for Adaptable Reliable Systems (STARS)

MasPar Computer Corporation

- Extended Scalable ASIMD Computing

Microelectronics and Computer Technology Corporation (MCC)

- Flexible Manufacturing of Multichip Modules

Mercury Computer Systems, Inc.

- Bridging the Development Gap

MITRE Corp.

- Real-Time Communications Scheduling
- Support for the DARPA HCI Program
- Support to DARPA/ITO for MAGIC and ACTS
- TBONE: Testbed for All-Optical Networking

MPC Corporation

- Early Evaluation and Development of CRAY T3D

Myricom, Inc.

- A Prototype Two-Level Multicomputer

National Semiconductor

- Reconfigurable Computing

Odyssey Research Associates, Inc.

- Task-based Authorization

Open Software Foundation, Inc. Research Institute

- Distributed Clients for Enhanced Usability, Reliability, and Adaptability in Accessing the National Information Environment.
- Distributed Group Authorization
- Distributed OS
- Embedded Real-Time OS
- Fault Handling and Customization
- POSIX Real-Time
- Secure, Scalable Operating Systems

Optivision, Inc.

- All-Optical Gigabit LAN
- Test Bed for Optical Networks (TBONE)

PRC Inc.

- TIPSTER Text Phase II SE/CM

Reliable Software Technologies Corporation

- Quantifying Minimum Time to Intrusion

Science and Technology Associates, Inc.

- EHPC Program Military Applications

Software Options, Inc.

- High Performance Computing Environments

Sprint

- ACTS ATM Internetwork (AAI)

SRI International

- MAGIC TerraVision Application
- Hierarchical Consistency Modeling for Next Generation Speech Recognition
- Highly Assured and Fault Tolerant Security in Distributed Systems
- Composing Megamodules and Compiling Megaprograms
- Real-time Traffic Distribution in Heterogeneous Environments
- SDTP: An Open Standard for Secure Distributed Transaction Processing

TASC, Inc.

- ImNet: High Performance Image Communications
- MIST (Multicast Implementation STudy)
- TBONE (Test Bed for all-Optical NEtworking)

Teknowledge Federal Systems

- Development of Domain Specific Software Architecture

Tera Computer Company

- Evaluation of Tera MTA Computer Systems
- High Bandwidth Connectivity for Multithreaded Microprocessors

Transarc Corporation

- Auto Indexing, Wide-Area File Access

Trusted Information Systems (TIS)

- ICE and Firewalls Task: International Cryptography Experiment (ICE)
- Internet Safety Through Type-Enforcing Firewalls
- INFOSEC for Networked Systems Task: Access Control and Authentication for Networked Systems
- INFOSEC for Networked Systems Task: Enhancement and Maintenance of Internet Privacy Enhanced Mail
- INFOSEC for Network Systems Task: Extended Secure Internet Access and Service (OVP)
- INFOSEC for Networked Systems Task: Network Security Standards and Operation
- INFOSEC for Networked Systems Task: Policy-Based Cryptographic Key Release System
- INFOSEC for Networked Systems Task: Replaceable TCB Elements
- INFOSEC for Networked Systems Task: Security Consulting and Cooperative Research
- Internet Infrastructure Protection
- Security and Interoperability for Heterogeneous Distributed Systems
- User-Level Truffles

Virtual Machine Works, Inc.

- A Technology for Low-Cost System Prototyping Based on Virtual Wires

Xerox Palo Alto Research Center

- ATM-Based Local Area Networks
- Multicast, Multimedia Infrastructure for the Internet
- Portable Parallel Preconditioning

Zycad Corporation

- SCOPE: Simulator COmbining Parallel processing and Emulation

米国政府による情報技術研究開発運営の現状と技術開発動向

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