



Computing at CERN - III

Summer Student Lectures 2002

Jamie Shiers

<http://cern.ch/jamie>

Lecture III

- Computing at CERN Today
- Software at CERN Today
- **The future & LHC Computing**



Homework

Review of homework from lecture 11

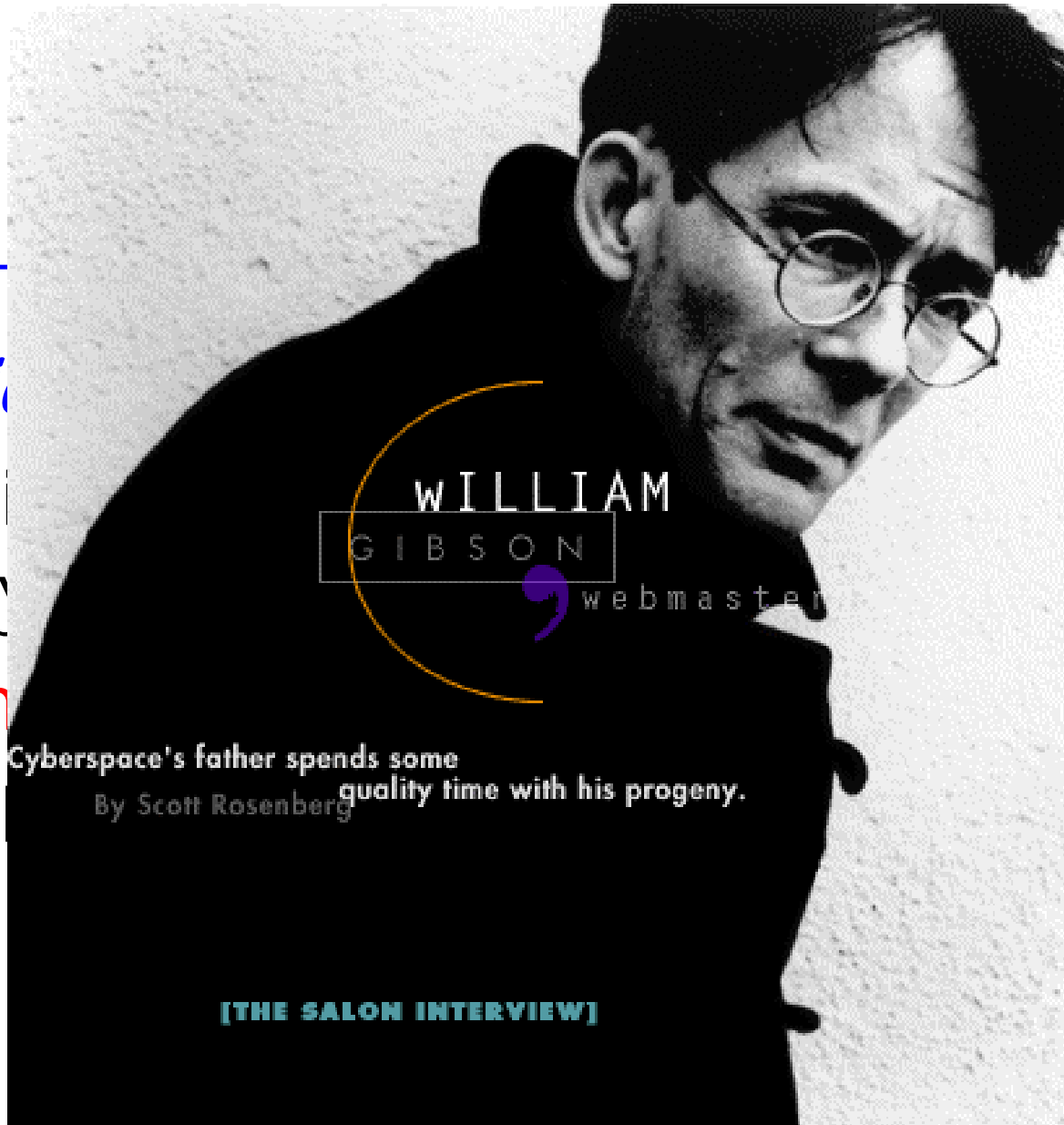
Exercise 11

- What will the CERN Computing environment look like in 10 years?
- Hint: some of the key elements exist today, albeit possibly in a different flavour.



Lecture III

- Computing at CERN Today
- Software at CERN Today
- **The future & LHC Computing**



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webmaster

Cyberspace's father spends some
quality time with his progeny.
By Scott Rosenberg

[THE SALON INTERVIEW]

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Predictions from 1945



- “As we may think”
 - Vannevar Bush
- Describes “memex”
 - A memex is a device in which an individual stores all his books, records, and communications, and which is mechanized so that it may be consulted with exceeding speed and flexibility. It is an enlarged intimate supplement to his memory.
- Used in much the same way as the Web

Lessons from the past

- ☠ Technologies explicitly designed to be the future rarely are...
 - Multics, ISO/OSI Network model, ADA, Alpha processor, Object Databases, Iridium, 3G, ...
- 😊 Very rapid advances in some areas
 - e.g. processor power, storage, ...
- ☹ Seemingly little in others...
 - Unix / Linux, Xerox PARC: Alto PC, Ethernet, distributed computing ... are all 1/4 century old!

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MICHAEL STONEBRAKER
PAUL BROWN
WITH DOROTHY MOORE

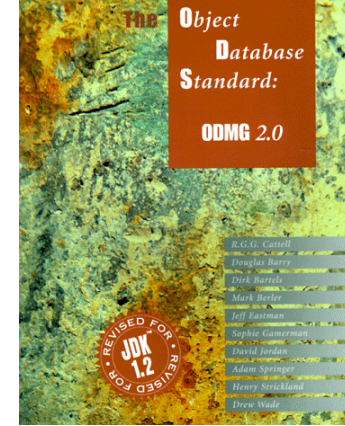


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OBJECT-RELATIONAL

DBMSs

TRACKING THE NEXT GREAT WAVE



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lace RDBMS

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The Future...

- Planning for the future:
 - Necessarily conservative: basically extrapolations of current / immediate technology
- Predicting the future:
 - Much more speculative ... and fun...

The Future's Here..

- Key predictions of Telecom 1999:
 - ✓ Convergence of mobile phones & PDA
 - Phones with main PDA apps built-in exist
 - Phones with full PDA functionality too...
 - ✗ Emergence of 3G networks
 - Lack of clear "killer app"
 - Down-loading ring-tones is clearly not it
 - ➔ Wireless networks offer strong competition



April Fool's Day...

- More computing power than the Apollo space programme...



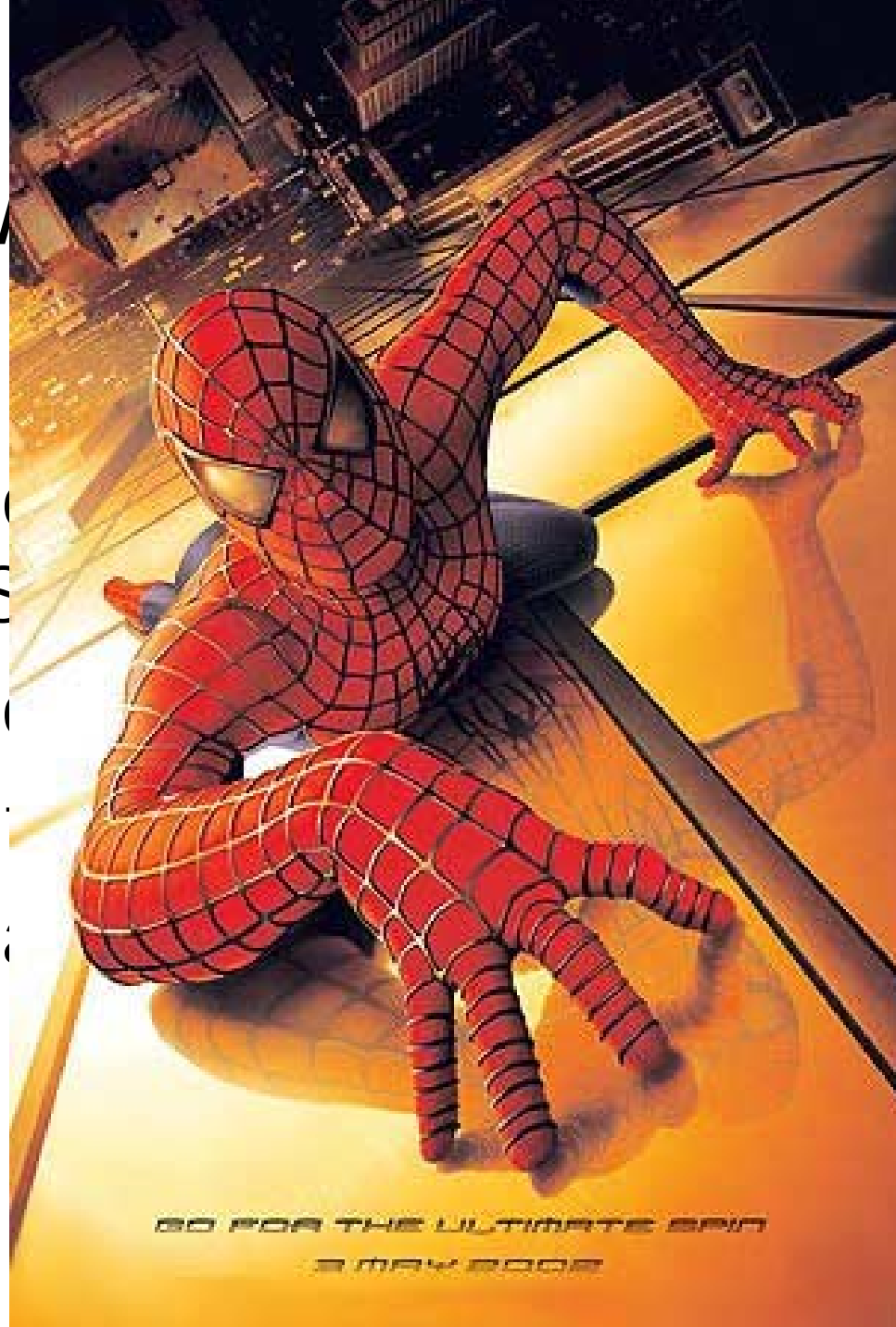
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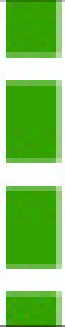
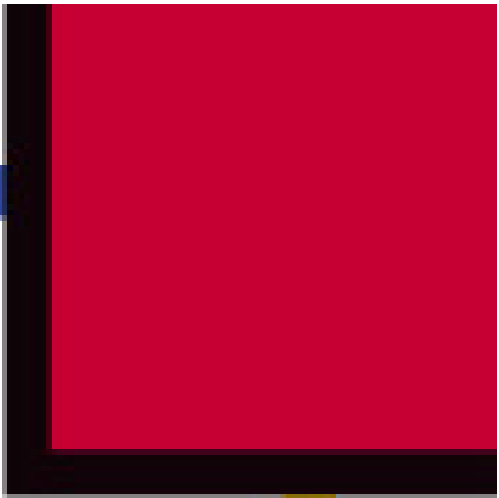
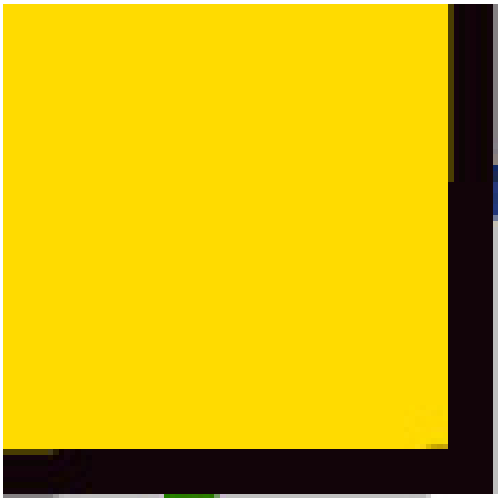
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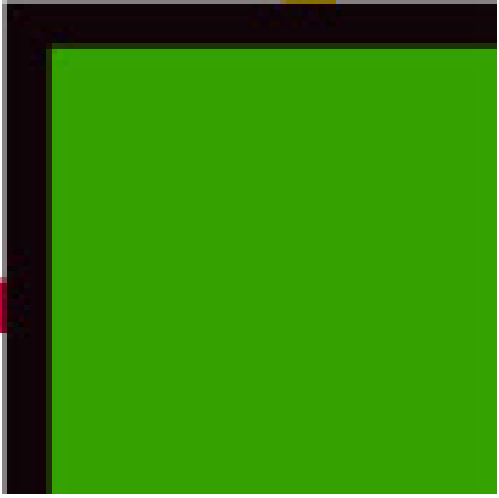
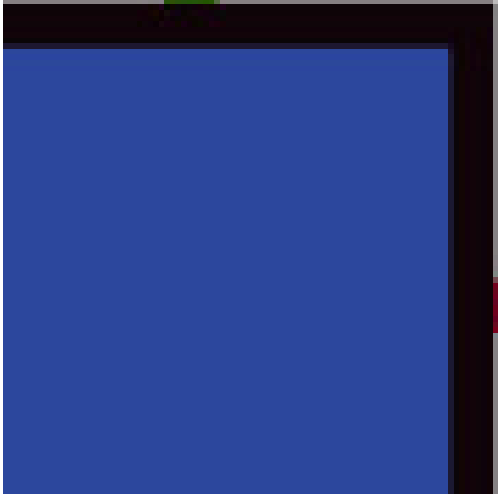
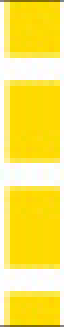


GO FOR THE ULTIMATE SPIN
 3 MAY 2008





L C G



Requirements per LHC Experiment

Processor power	$> 10^6$ SPECint95
Data volume	$> 2\text{PB} / \text{year}$
Data rate	$> 1\text{Tbit} / \text{second}$
# addressable objects	$> 10^9$
# users	10^3
# data traversals	$10 - 10^2$

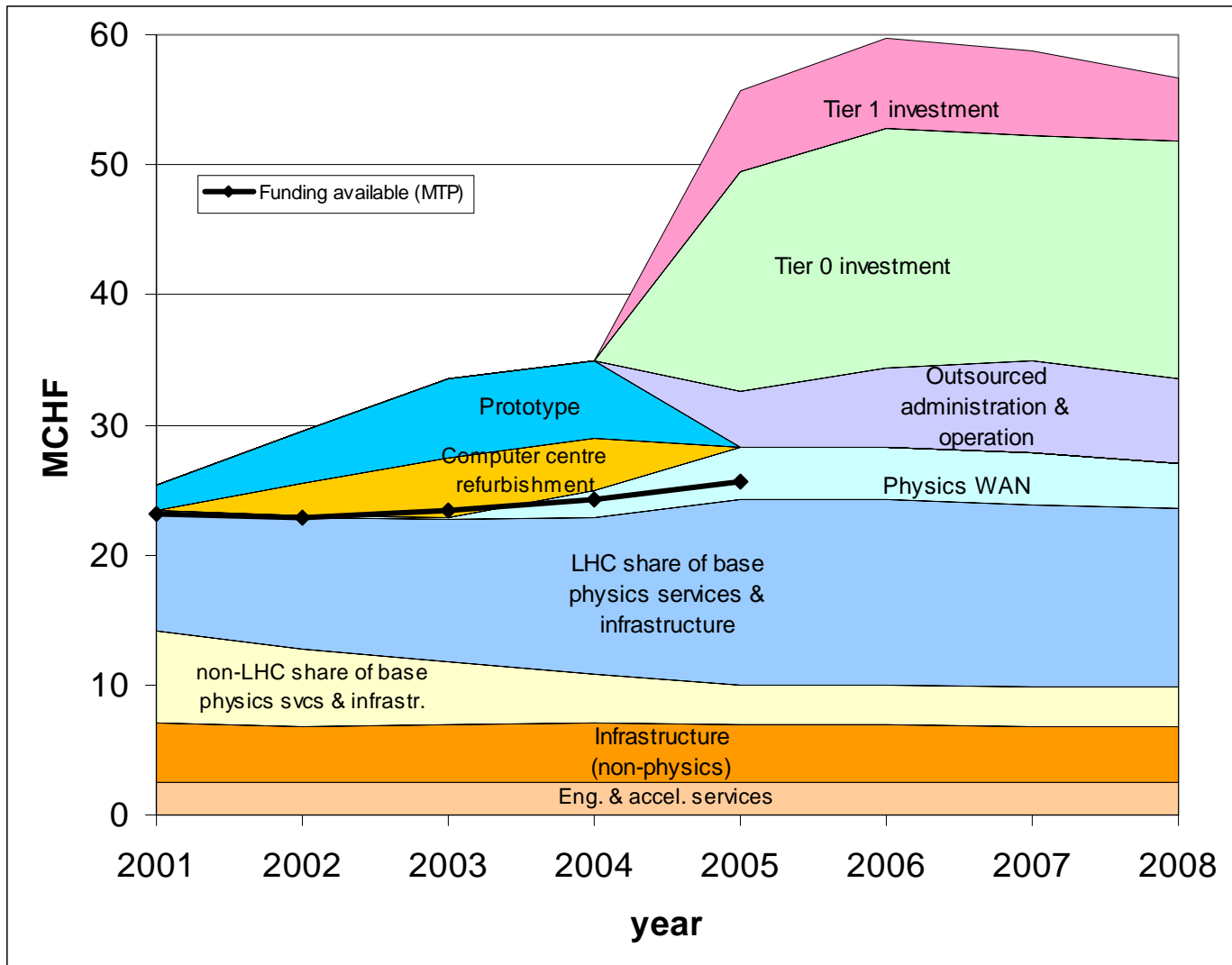
Few GB/s per PB

HEP Computing Characteristics

- Large numbers of independent events
 - ✓ trivial parallelism
- Large data sets
 - ✓ smallish records; mostly read-only
- Modest I/O rates
 - ✓ few MB/sec per fast processor
- Modest floating point requirement
 - ✓ SPECint performance

☹ **Very large aggregate** requirements

Cost Estimates for CERN

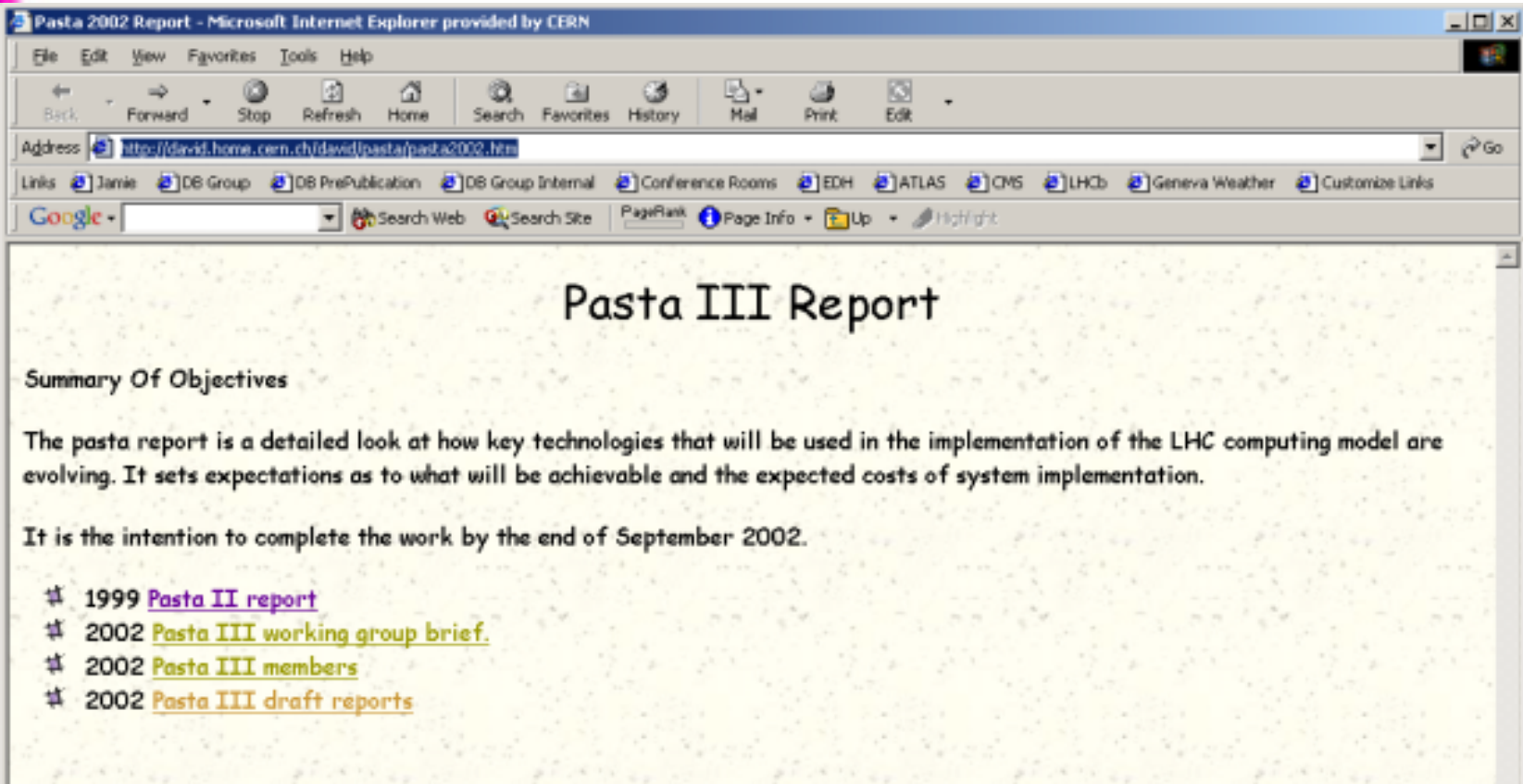


Evolution of LHC Prototype

Capacity							
	<i>year</i>	2001	2002	2003	2004	2005	
<u>processor farm</u>							
no. of 2-cpu systems installed		182	400	400	600	800	
estimated total capacity (SI95)		15000	33000	33000	69800	121800	
<u>disk storage</u>							
no. of disks installed		200	480	480	960	1600	
estimated total capacity (TB)		15	47	47	143	271	
<u>tape drives</u>							
total capacity (achievable MB/sec)		150	350	450	600	800	
<u>automated media</u>							
total capacity (TB)		30	100	200	400	600	

PASTA

CERN Technology Tracking for the LHC



Pasta 2002 Report - Microsoft Internet Explorer provided by CERN

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Back Forward Stop Refresh Home Search Favorites History Mail Print Edit

Address <http://david.home.cern.ch/david/pasta/pasta2002.htm> Go

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Pasta III Report

Summary Of Objectives

The pasta report is a detailed look at how key technologies that will be used in the implementation of the LHC computing model are evolving. It sets expectations as to what will be achievable and the expected costs of system implementation.

It is the intention to complete the work by the end of September 2002.

- ✦ 1999 [Pasta II report](#)
- ✦ 2002 [Pasta III working group brief.](#)
- ✦ 2002 [Pasta III members](#)
- ✦ 2002 [Pasta III draft reports](#)

<http://cern.ch/david/pasta/pasta2002.htm>

Modified: 17th April 2002
Contact: [David Foster](#)



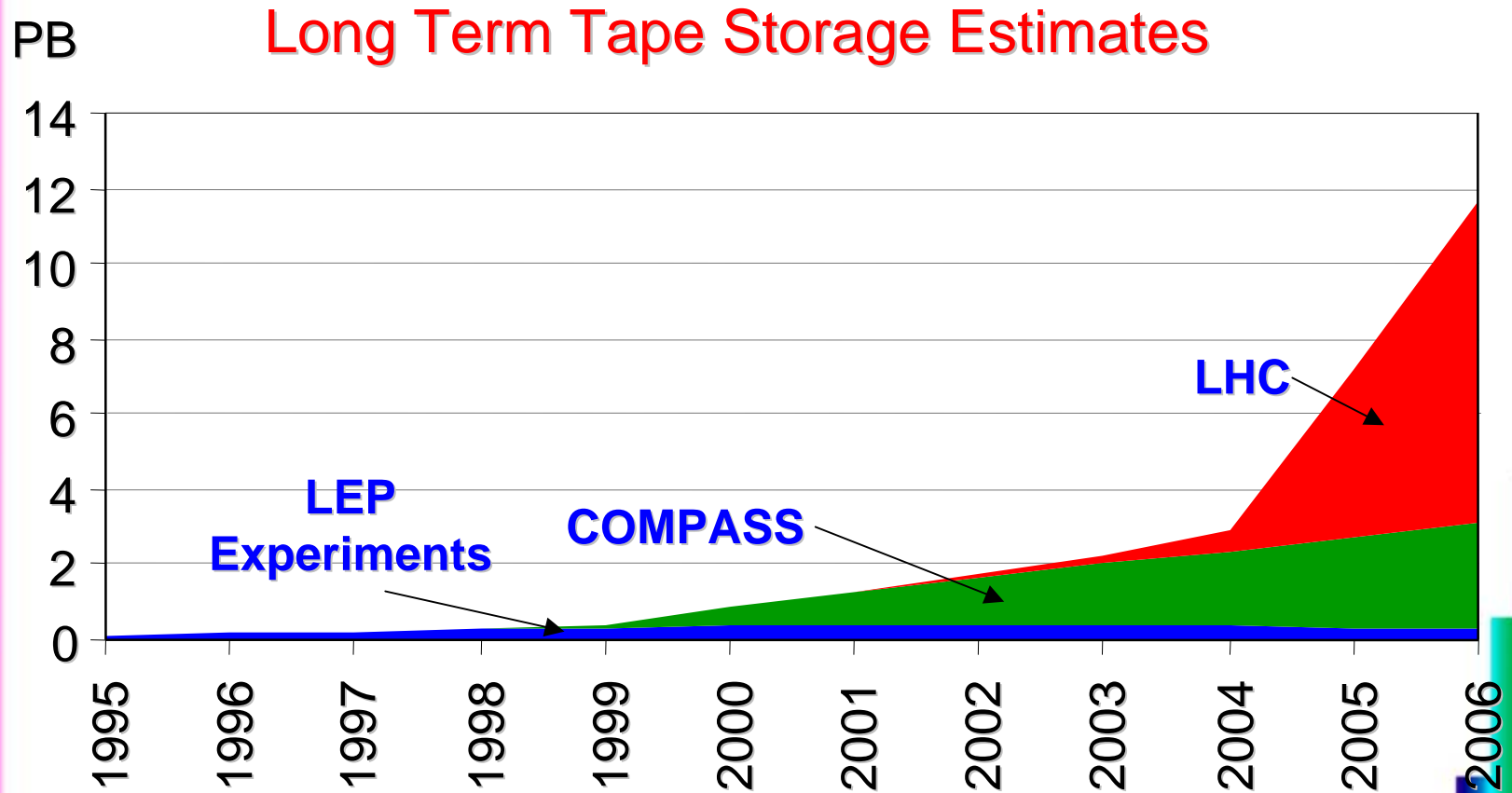
Storage
Predictions

Storage Colloquium

- Wednesday 7th August, 14:00, main auditorium
- Jai Menon, IBM Storage Research
 - Storage Tank, IceCube



LHC - A Multi-PB Problem!



LHC Data Volumes

Data Category	Annual	Total
RAW	1-3PB	10-30PB
Event Summary Data - ESD	100-500TB	1-5PB
Analysis Object Data - AOD	10TB	100TB
TAG	1TB	10TB
Total per experiment	~4PB	~40PB
Grand totals (15 years)	~16PB	~250PB

IBM RAMAC - 1956

- Stored 5 million characters on 50 24 inch disks
- Recording surface painted with same paint as Golden Gate!
- Disk evolution should allow 100TB - 1PB disks towards end of LHC era



Where's the limit?

- Physical limits make prediction beyond 100x today's densities hard
- Future types of storage, e.g. holographic, may provide road ahead
- But is there a market for such enormous disks???
- Particularly a commodity market,
 - i.e. your PC

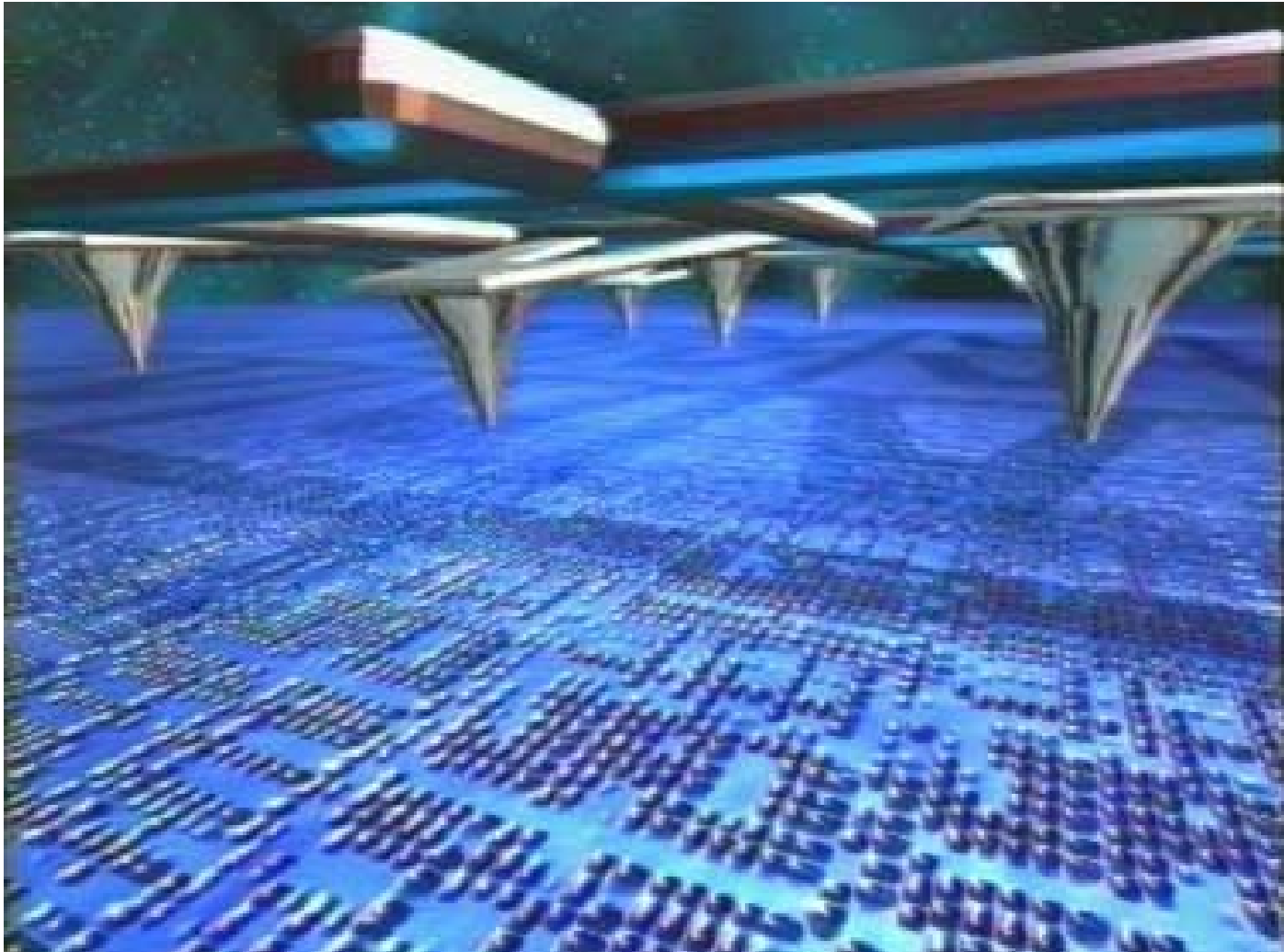
Storage Needs

- Extrapolating from today's reality into future always dangerous
 - T.J.Watson Jr., Ken Olsen, ...
- Will tomorrow's humans record everything that they ever see?
 - From Jim Gray:
 - *1-10GB e-mail, PDF, PPT,*
 - *10-50GB in mpeg, jpeg, ...*
 - *1TB+ voice + video*
 - *Video can drive this towards 1PB*
 - In other words, **1PB of personal data...**

IBM Millipede...

- "The system can store 400 gigabytes per square inch. A prototype, measuring just 3mm square, stores just under 1 gigabyte of data."
- "in five to 10 years the world may see devices the size of a dime that are capable of storing a terabit of data, which is 125 gigabytes, or 1 trillion bits"
- Rumours that IBM sold its disk business to Hitachi due to Millipede...

Millipede cont.



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Storage - Predictions

- The personal petabyte





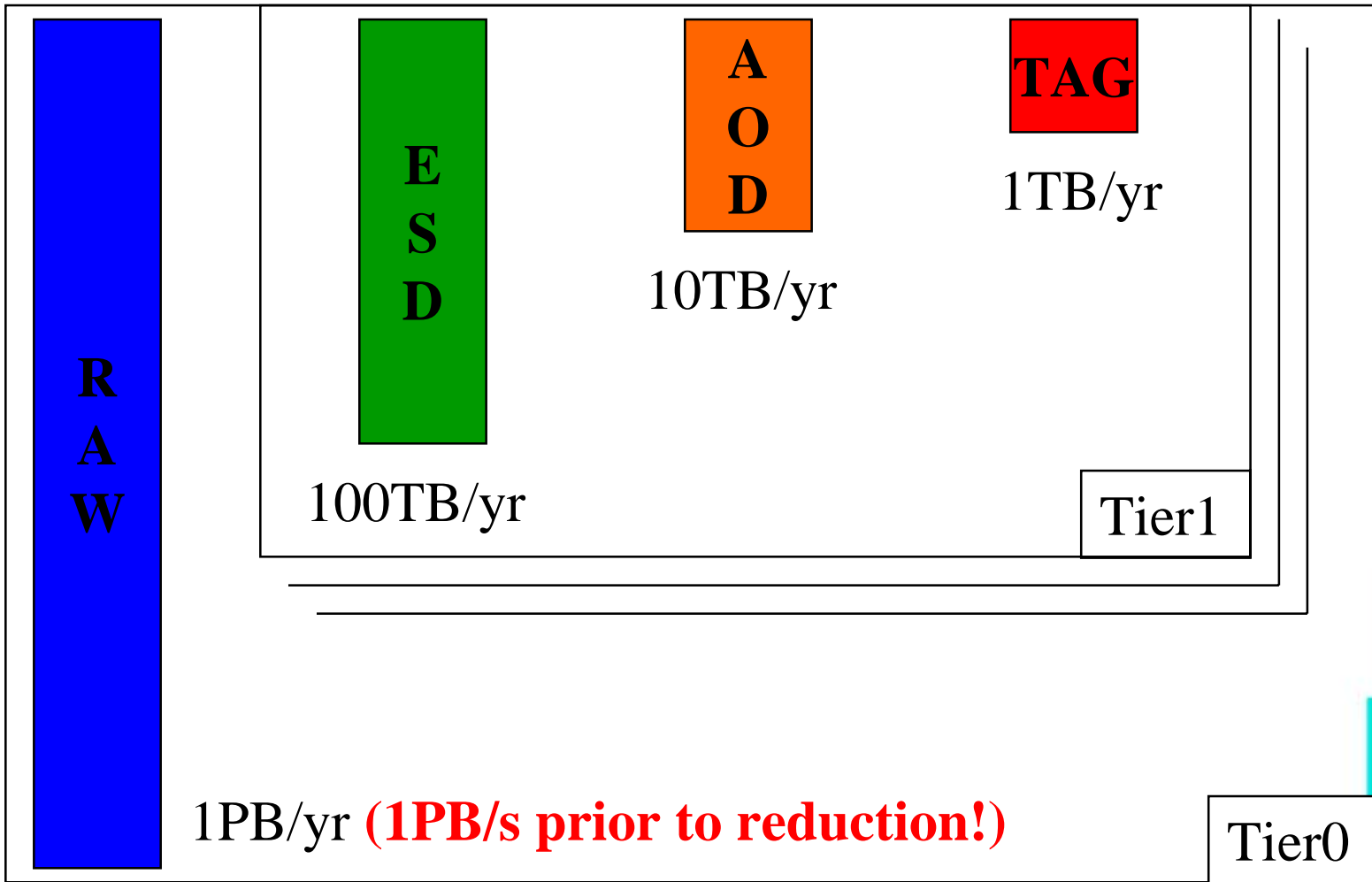
Database Predictions

Databases & HEP



- 1995 on:
 - Distributed Object Database for all data (meta-data, event data, ...)
- Current thinking:
 - Metadata in a database
 - Bulk data in flat files
- LCG Persistency Framework (POOL)
- On-going work with ORDBMS
 - CHORUS, COMPASS, HARP, ...

Data



1PB/yr (1PB/s prior to reduction!)

100TB/yr

10TB/yr

1TB/yr

Tier1

Tier0

seq.

random

Users

Database Predictions

- VLDB: yotabytes by 2020
 - 1,000,000,000 PB
- IBM "Global Technology Outlook"
 - zetabytes by 2010
 - 1,000,000 PB

Marking the Millennium

26th International Conference on Very Large Databases
Cairo, Egypt, 10-14 September 2000



Reality of Databases Today

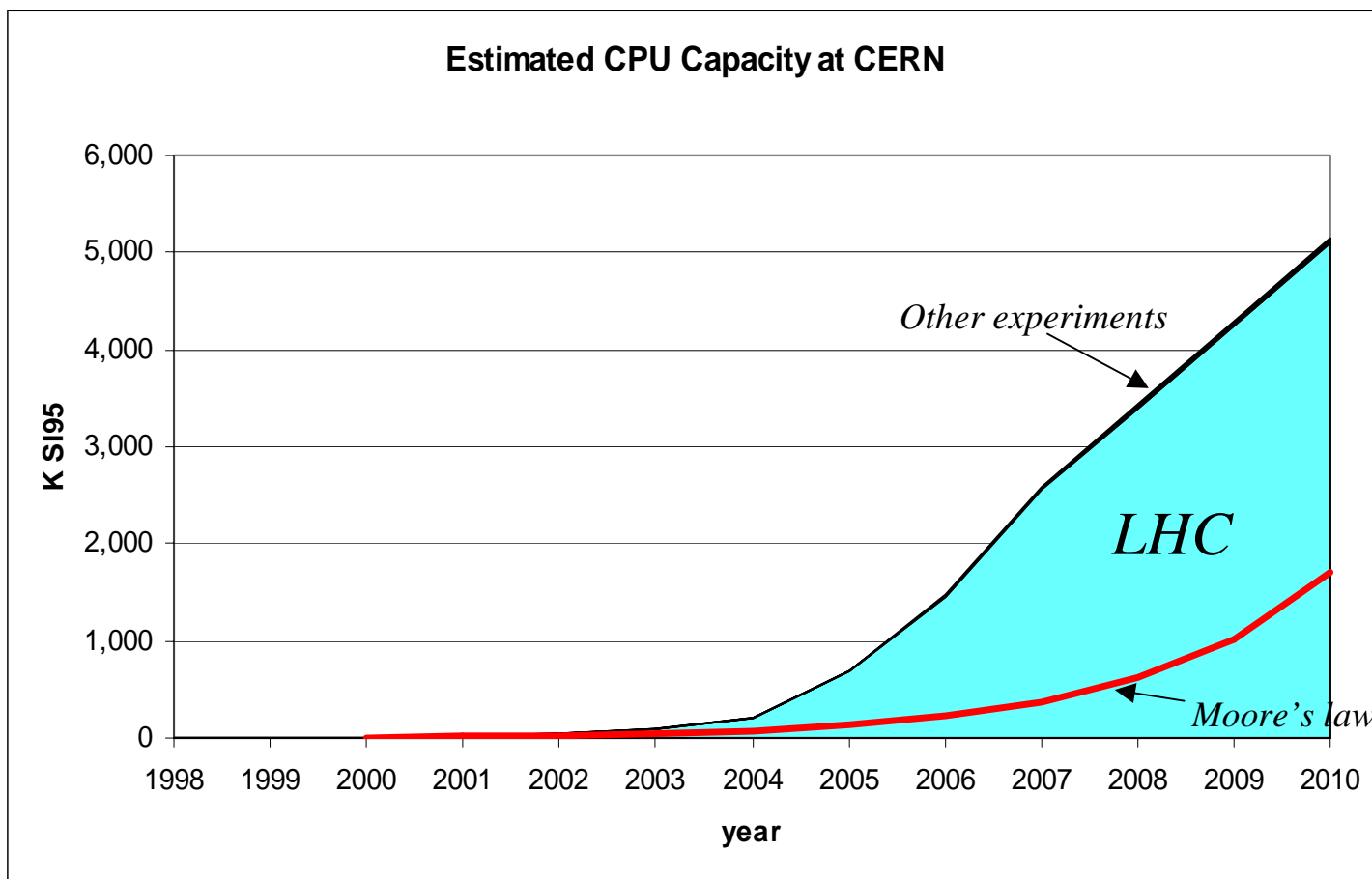
- Largest known database: 500TB
 - BaBar experiment at SLAC
- Many databases in 1-10TB range
 - "Management limit" - Jim Gray
- Vendors targetting PB in immediate future





CPU Predictions

Super-Moore's Law



Itanium[®] Processor Family

Performance

Software scales across generations

Common hardware

Itanium[®]
Processor

- Introduce architecture
- Deliver competitive performance
- Focused target segments

2001

Itanium[®] 2
Processor

- Build-out architecture/ platform
- Establish world-class performance
- Significantly increase deployment

2002

Madison* /
Deerfield*

- Extend performance leadership
- Broaden target applications

2003

Montecito*

* Indicate Intel processor codenames. All products, dates and figures are preliminary, for planning purposes only, and subject to change without notice.



Grid

A Document Preparation System

L^AT_EX

USER'S GUIDE AND
REFERENCE MANUAL



Leslie Lamport

Updated for
L^AT_EX 2_ε

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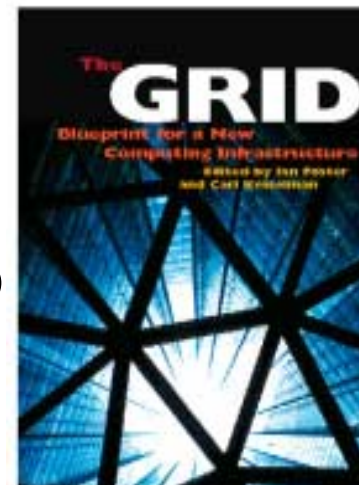


The Grid

- Overview – see DG's introductory talks
- Detail – see Tony Hey's talk on August 21
 - eBusiness, eScience & the Grid
- CERN & the Grid
 - Many projects, specifically:
 - EU Data Grid (EDG)
 - LHC Computing Grid (LCG)

The Grid vision

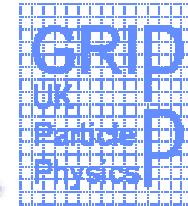
- Flexible, secure, coordinated resource sharing among dynamic collections of individuals, institutions, and resource
 - From "The Anatomy of the Grid: Enabling Scalable Virtual Organizations"
- Enable communities ("virtual organizations") to share geographically distributed resources as they pursue common goals -- *assuming the absence of...*
 - central location,
 - central control,
 - omniscience,
 - existing trust relationship



Grids: Elements of the Problem

- Resource sharing
 - Computers, storage, sensors, networks, ...
 - Sharing always conditional: issues of trust, policy, negotiation, payment, ...
- Coordinated problem solving
 - Beyond client-server: distributed data analysis, computation, collaboration, ...
- Dynamic, multi-institutional virtual orgs
 - Community overlays on classic org structures
 - Large or small, static or dynamic

Grid R&D Projects



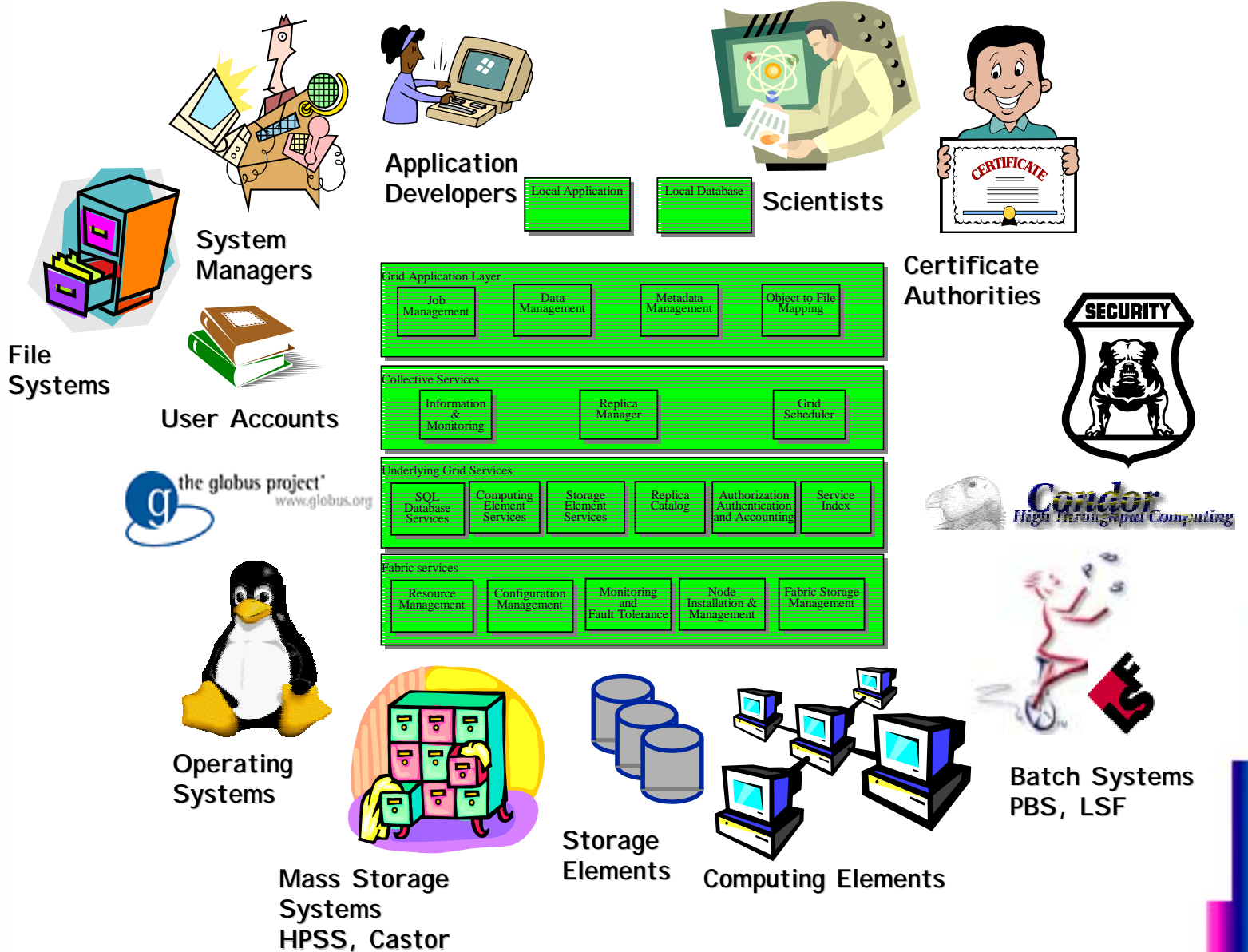
Many national, regional Grid projects -- GridPP(UK), INFN-grid(I), NorduGrid, Dutch Grid, ...

US projects

European projects

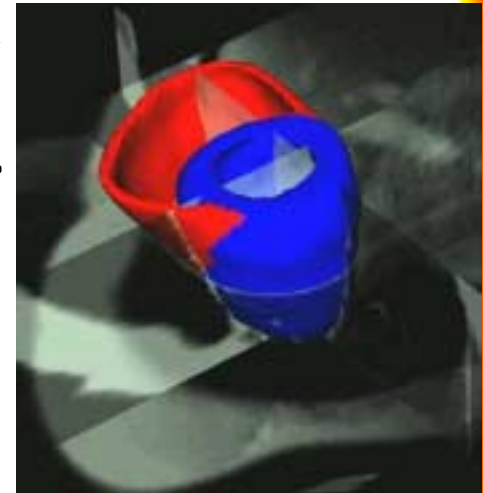
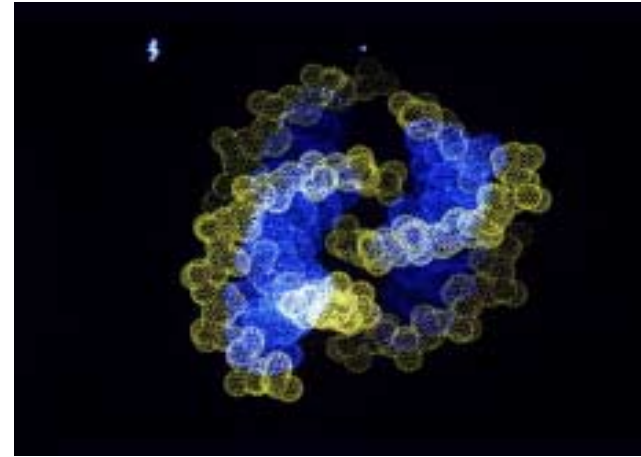


EDG Interfaces



Biomedical applications

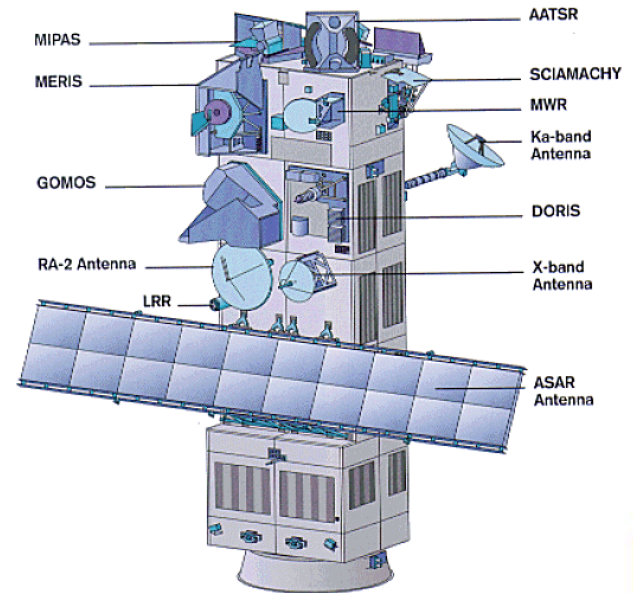
- Data mining on genomic databases (exponential growth)
- Indexing of medical databases (Tb/hospital/year)
- Collaborative framework for large scale experiments (e.g. epidemiological studies)
- Parallel processing for
 - Databases analysis
 - Complex 3D modelling



Earth Observations

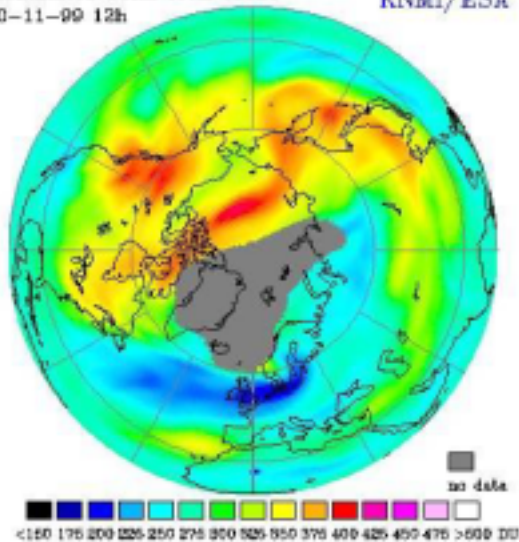
ESA missions:

- about 100 GB of data per day (ERS 1/2)
- 500 GB for the next ENVISAT mission (launched March 1st)



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30-11-99 12h

KNMI/ESA




EO requirements for the Grid:

- enhance the ability to access high level products
- allow reprocessing of large historical archives
- improve Earth science complex applications (data fusion, data mining, modelling ...)



Grids & Industry

- Strong push from major vendors, including IBM and others
 - e.g. Sun, Microsoft, ...
 - Consistent message of Grid as “next generation of Internet”
 - Networking (TCP/IP)
 - Communications (e-mail)
 - Information (World Wide Web)
 - Computing (Grid)
- 

The Internet as a Computing Platform

Key Challenges / Initiatives

- **Building an open infrastructure**
 - ▶ **Grid Computing Protocols**

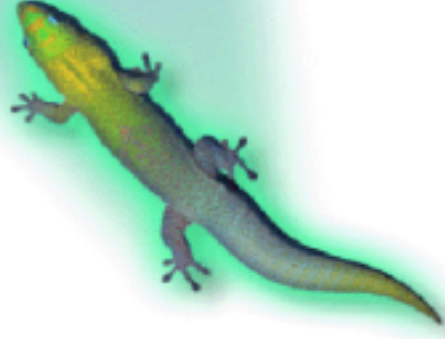
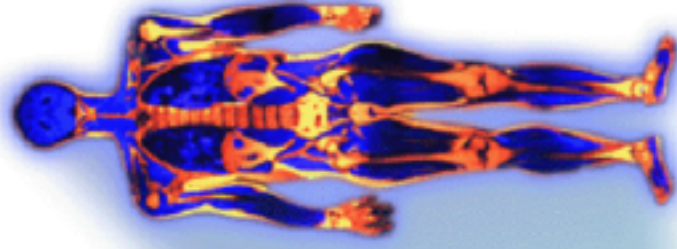
- **Managing the infrastructure**
 - ▶ **Autonomic Computing**

- **Accessing the infrastructure**
 - ▶ **"Utility" Computing**



Autonomic Computing

- Self-optimizing
- Self-configuring
- Self-healing
- Self-protecting



"Utility" Computing Examples

Canadian Tire



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Oct. 17, 2001
 Better hurry,
 before you know
 it, you will miss
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 Tuesday, October 16, 2001

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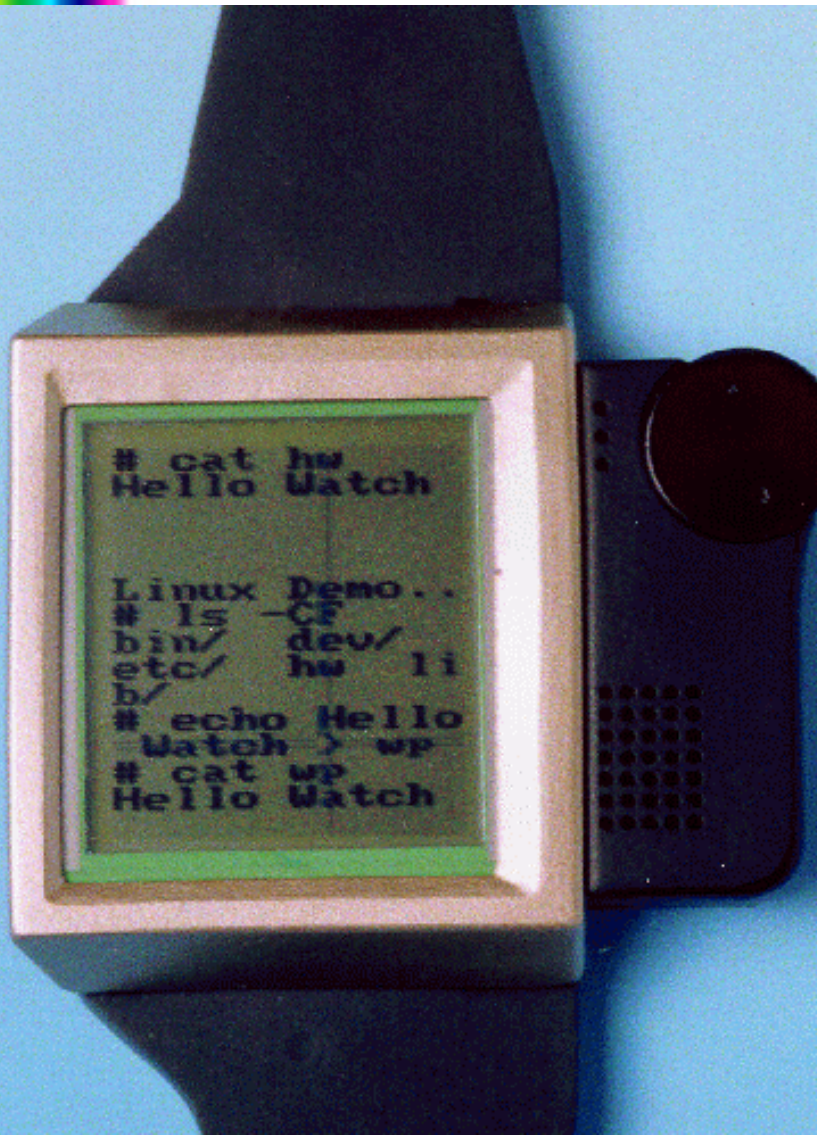
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Holiday
 with Energy



Computing
Predictions

Wearable Computers





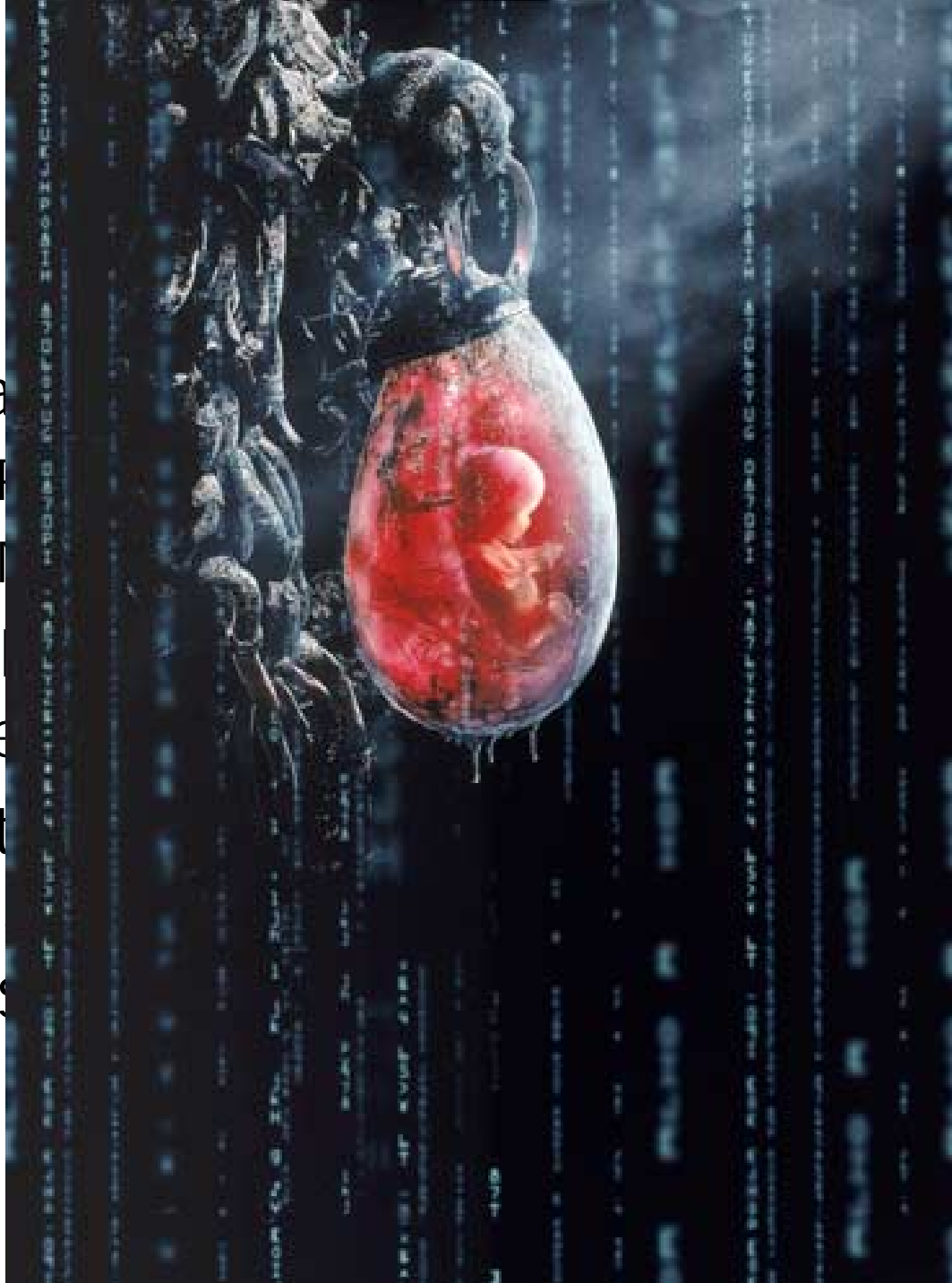
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Smart Dust

- Develop complete sensor / communication system into 1 mm^3
 - "Grain of sand" also mentioned...
- Potential applications:
 - Virtual keyboard
 - Inventory control
 - Product quality monitoring
 - Smart office spaces

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Smart Dust again

- “Scavenging power from sunlight, vibration, thermal gradients, and background RF, sensors motes will be immortal, completely self contained, single chip computers with sensing, communication, and power supply built in.
- Entirely solid state, and with no natural decay processes, they may well survive the human race. Descendants of dolphins may mine them from arctic ice and marvel at the extinct technology.”



The last 100 years...



Population	4
Horses	1.1
Forest area	0.8
Blue whales	0.0025 (1/400)
World economy	14
Energy use	13
CO ₂ emissions	17
Industrial output	40
Computers	?

Predictions from 1945



- “As we may think”
 - Vannevar Bush
- Describes “memex”
 - A memex is a device in which an individual stores all his books, records, and communications, and which is mechanized so that it may be consulted with exceeding speed and flexibility. It is an enlarged intimate supplement to his memory.
- Used in much the same way as the Web

Predictions from 2000

- In 2010, everything worth more than a few \$ will know that its yours...
- A speck of dust on each fingernail will communicate with your computer
- Your house, office and car will be continuously aware of your presence
- Tyres will communicate with the on-board computer if pressure is low, your milk carton will signal if the contents are off...
- In 2020, sensors will monitor all major bodily systems, providing early warning of diseases...



Summary


Summary I

- We've looked at:
 - The birth of IBM,
 - The IBM PC,
 - Unix, then Linux,
 - The Internet, The Web,
 - GUI / mouse, ...



Summary I I

Producing high-quality software is:

- Far from easy
 - Far from cheap
 - Still not a solved problem
- 



Discussion Session

Friday 26th July, 11:15, main amphitheatre



Further Reading

Some Links

<http://www.h2g2.com/>

<http://www.bbc.co.uk/cult/doctorwho/>

<http://cern.ch/ssl-computing/default.htm>



Acknowledgements

Many in I T, CERN and anyone
who's put something on the Web



Homework

BACK TO THE FUTURE





End Lecture III