Communication networks in the next decade

integrating very high-speed networks and ubiquitous communicating devices

ACOMP 2007, HCMC, Vietnam

March 15th, 2007

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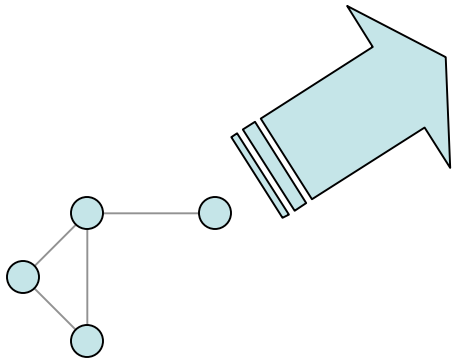
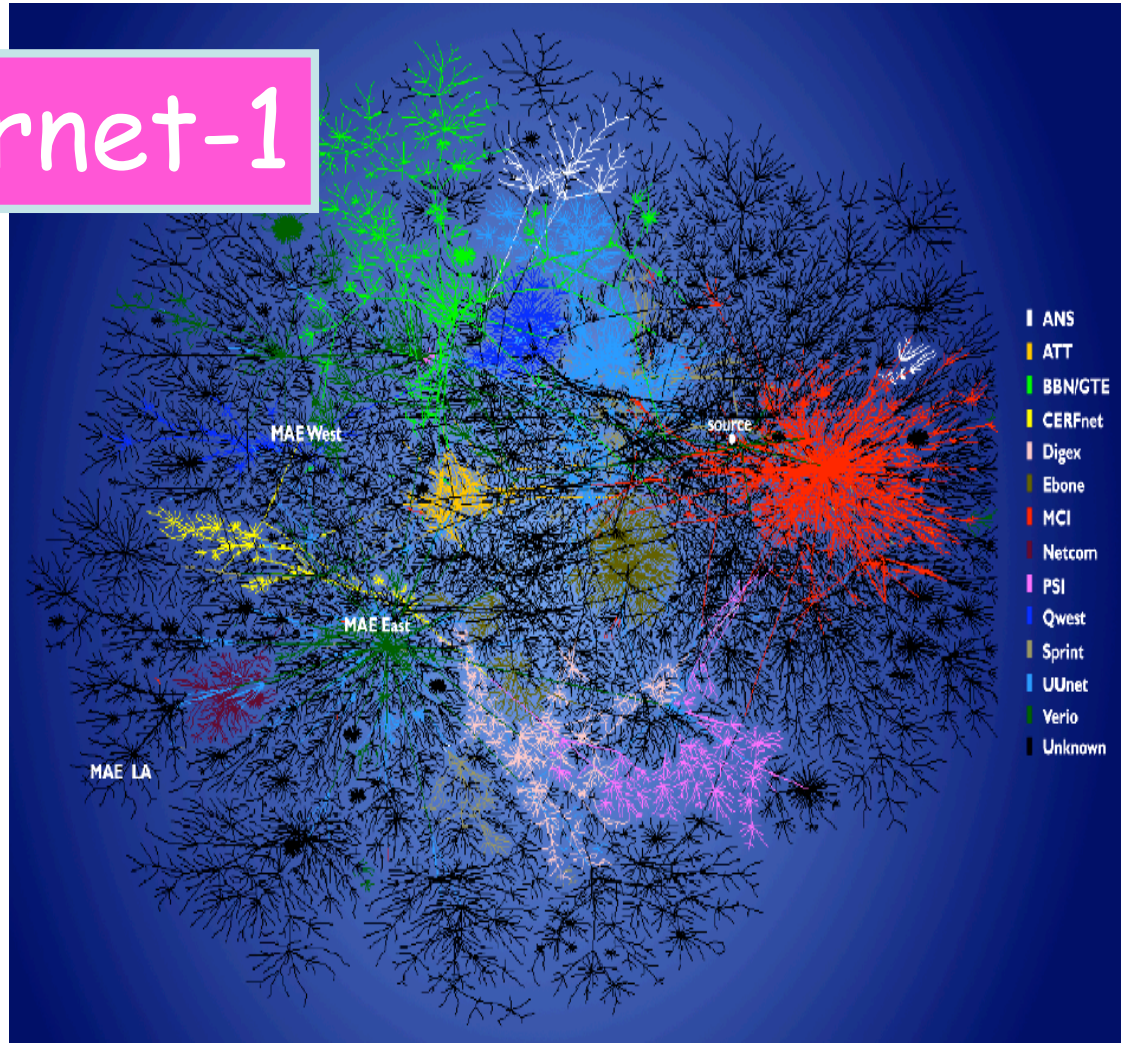
http://www.univ-pau.fr/~cpham

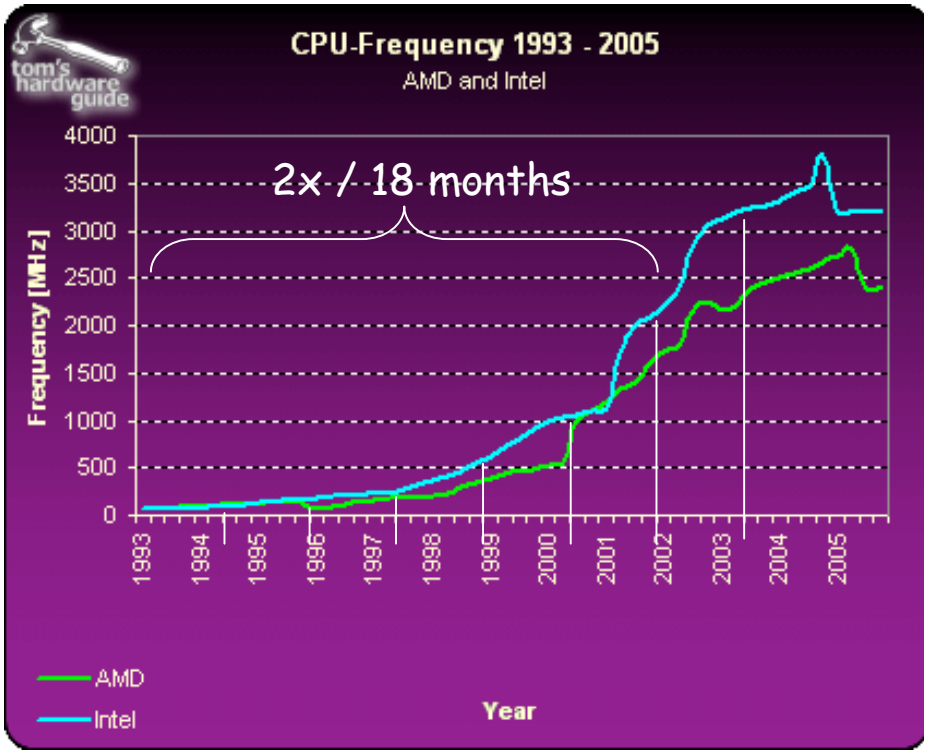
Big-bang of the Internet

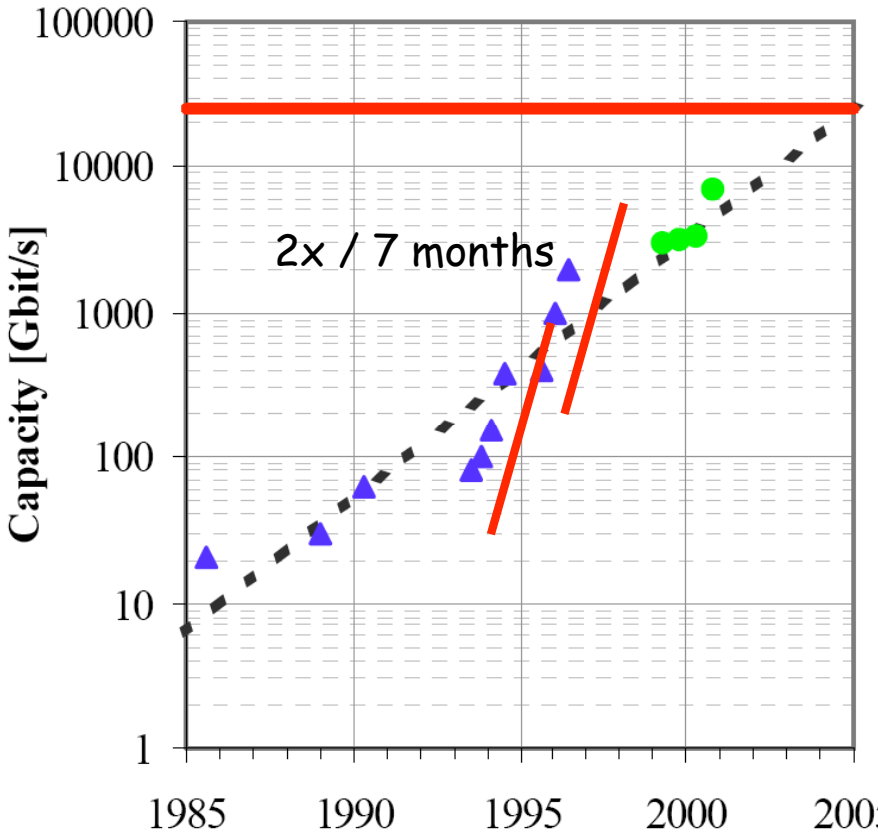
Internet-1





1st revolution: optical transmission

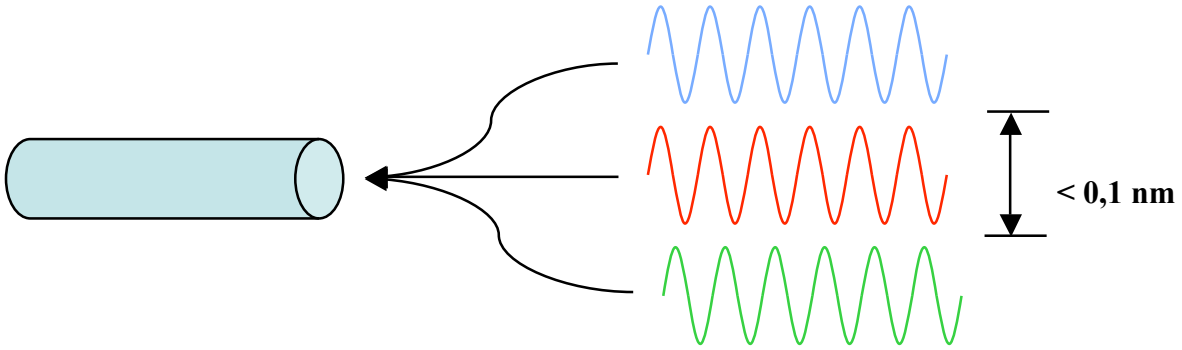


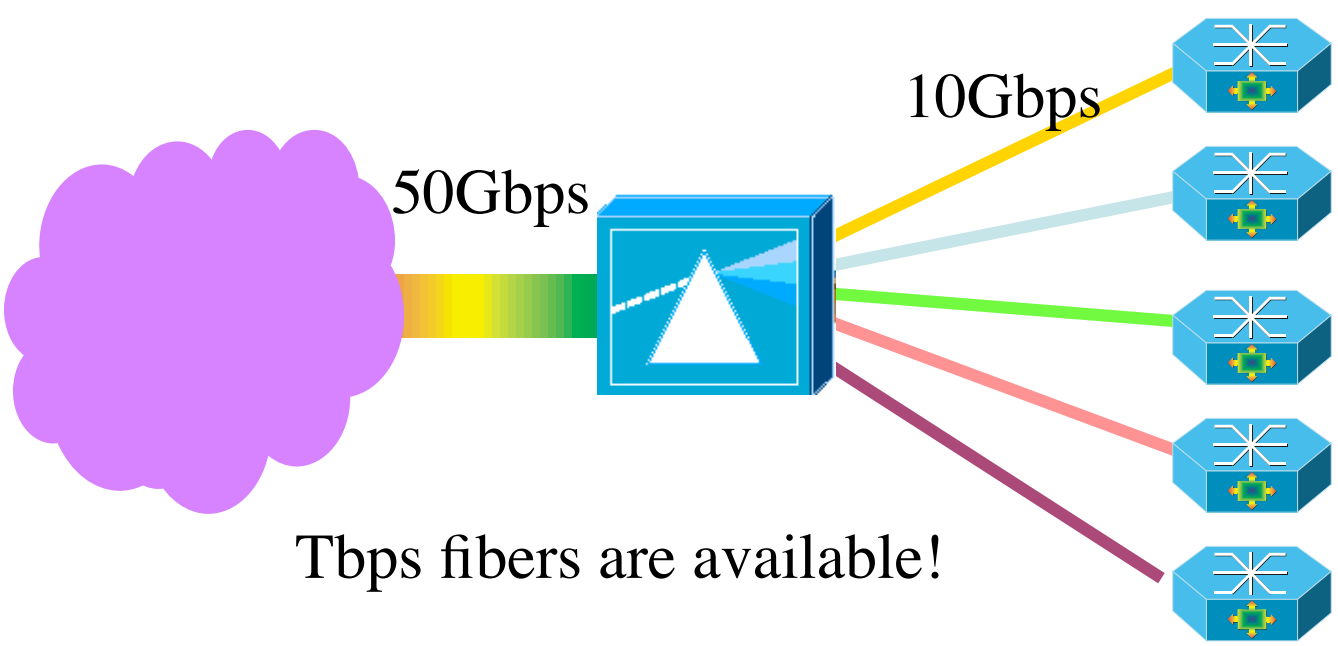


Source « Optical fibers for Ultra-Large Capacity Transmission » by J. Grochocinski

Bandwidth for free?

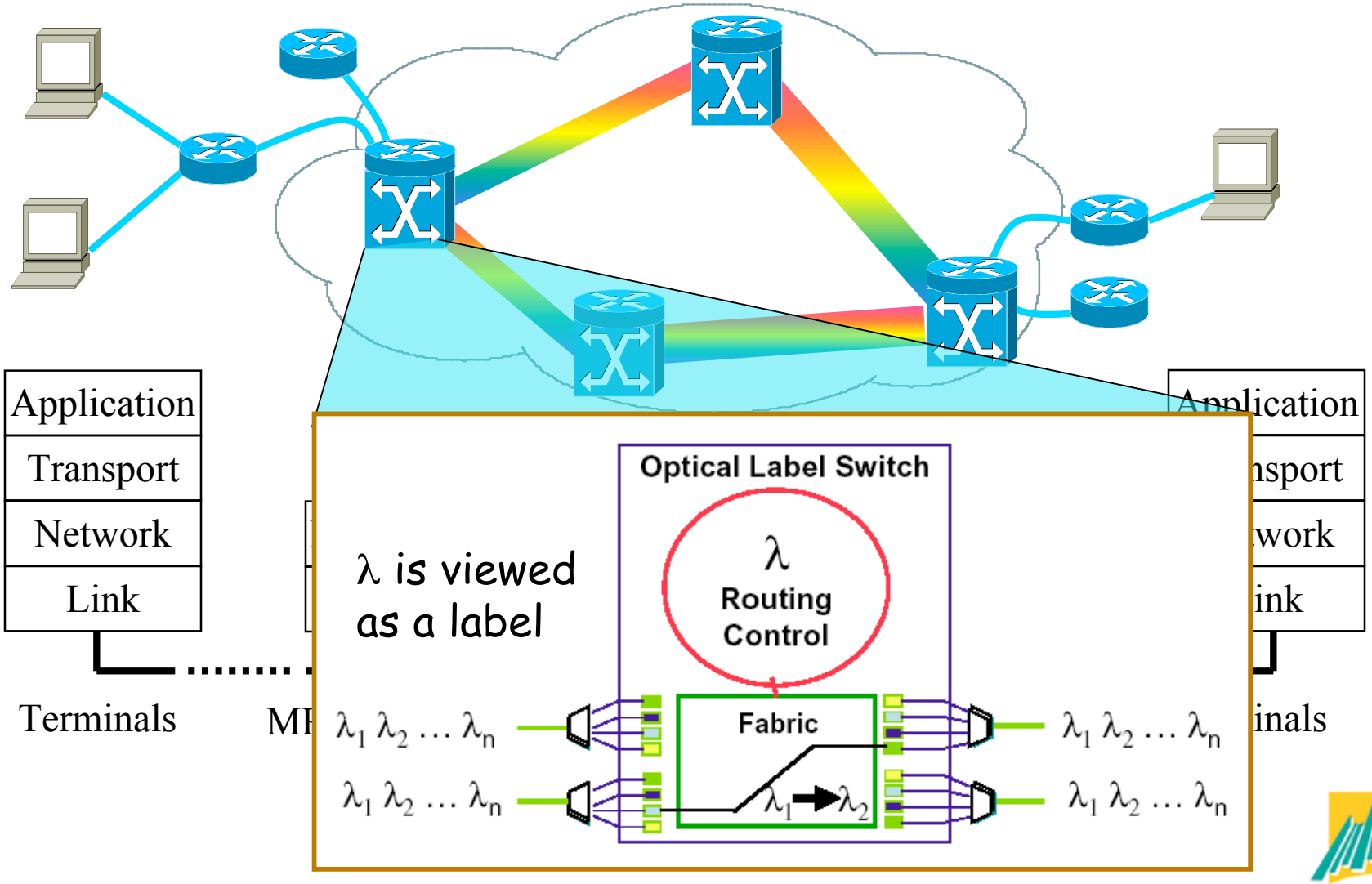
DWDM: Dense Wavelength Division Multiplexing





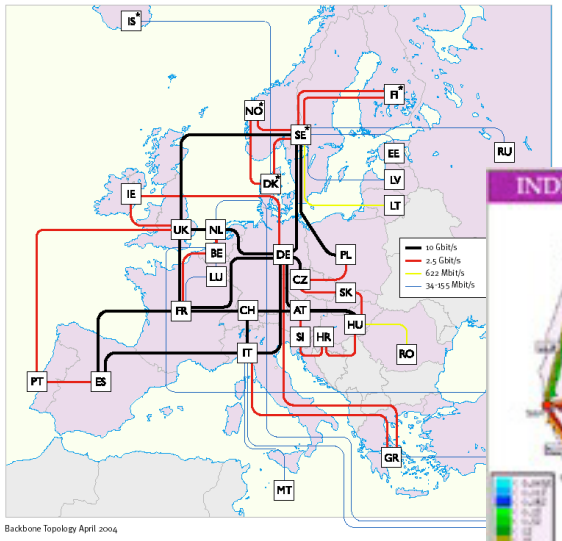
Tbps fibers are available!

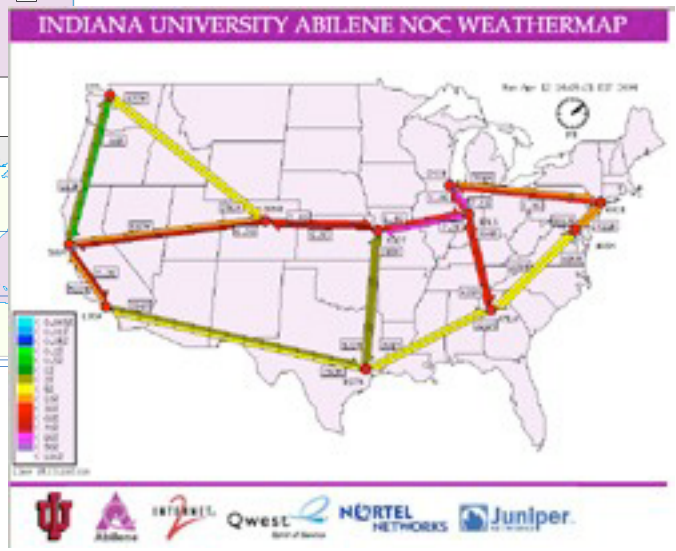
Optical networking



The new networks

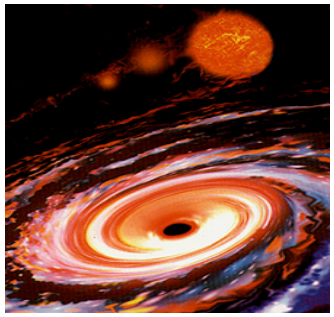
- vBNS
- Abilene
- SUPERNET
- DREN
- CA*NET
- GEANT
- DATATAG
- …much more to come!





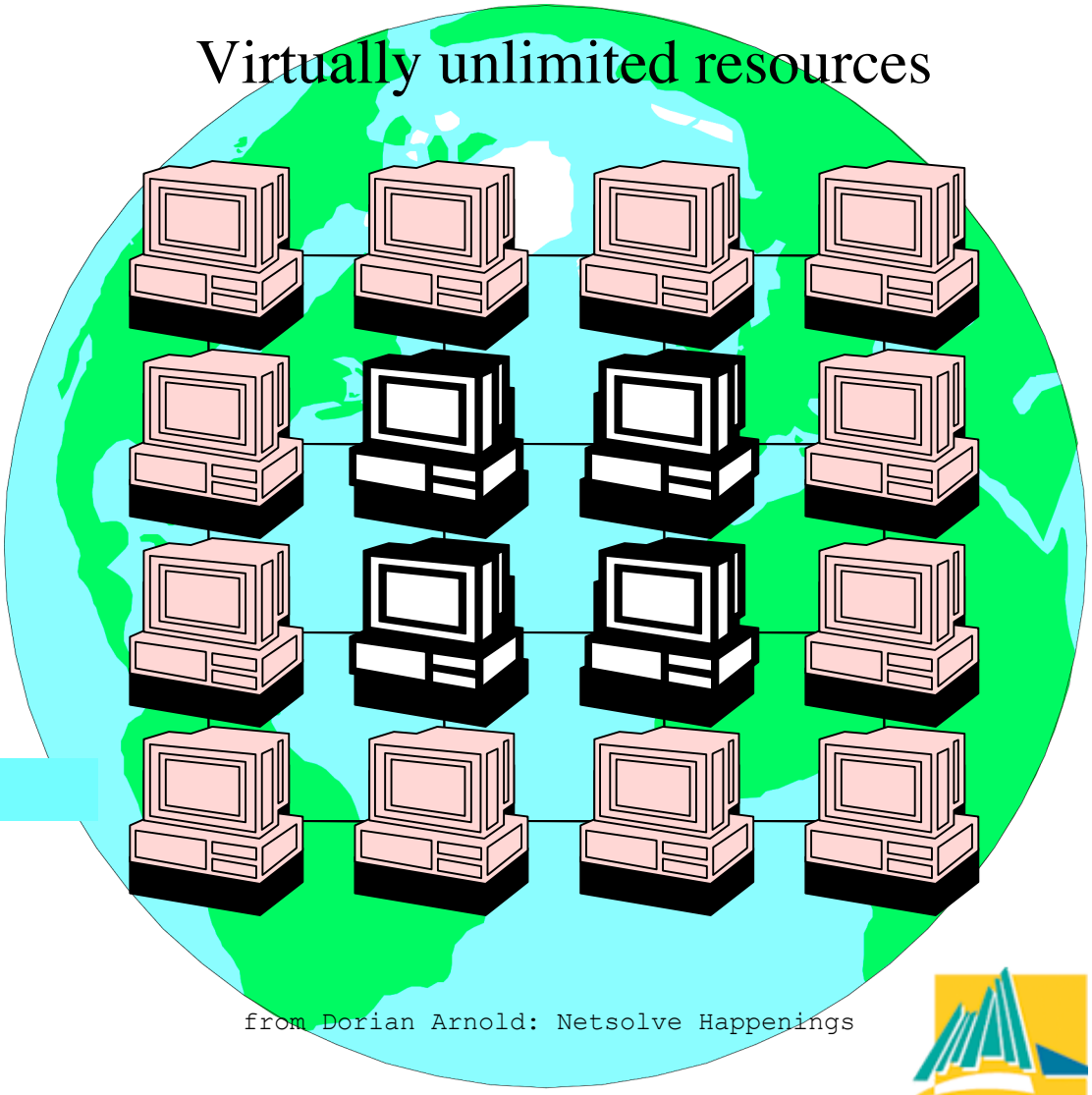
Computational grids

user application



1PFlops

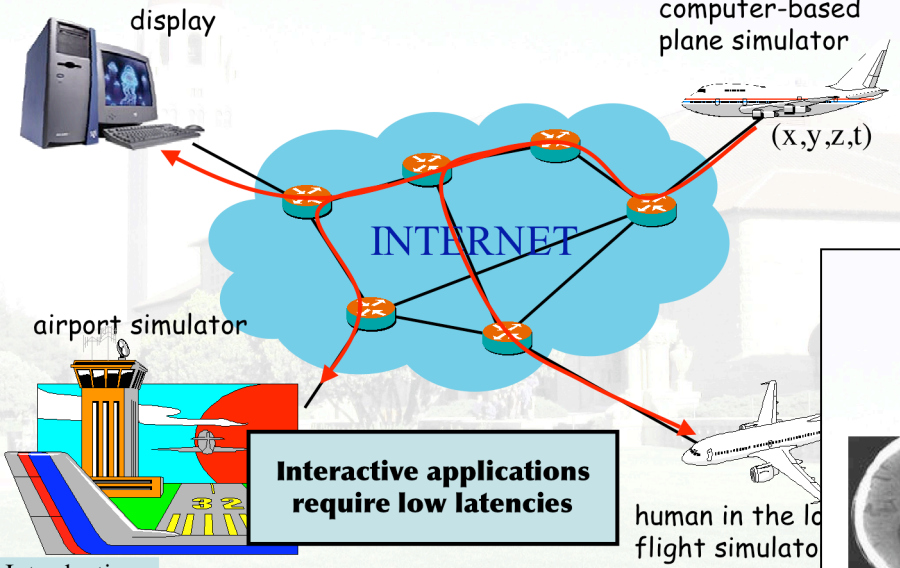
Virtually unlimited resources



from Dorian Arnold: Netsolve Happenings

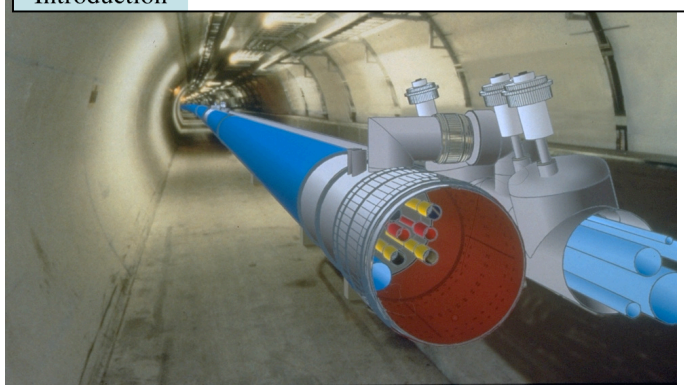
Large variety of applications

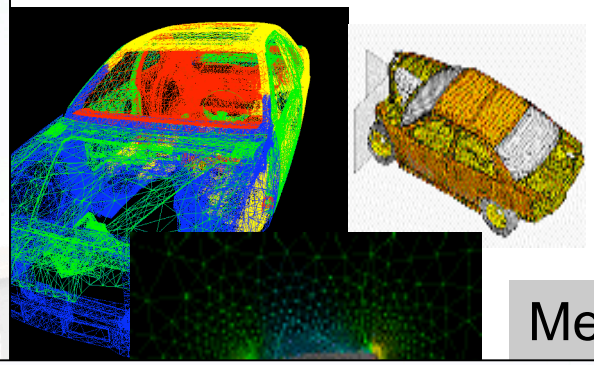
Wide-area interactive simulations



Interactive applications require low latencies

Introduction

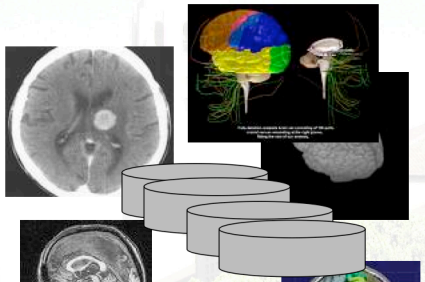




Mechanics:

Funda
Mass s

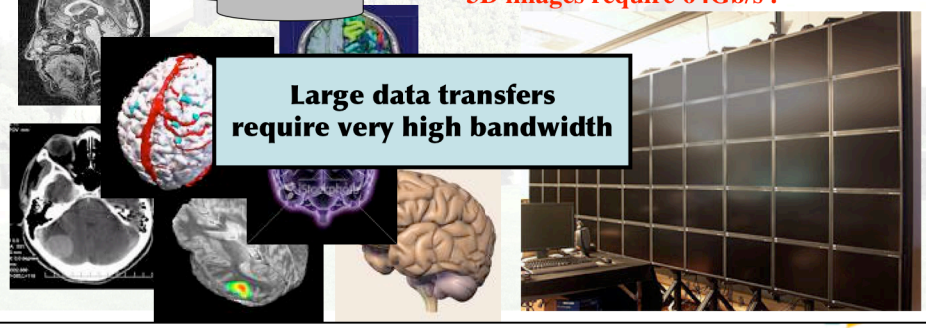
Real-time interactive large-scale scientific collaborations



Multimodality brain mapping

require the ability to process, share, and interactively visualize multiple 100Gbytes datasets!

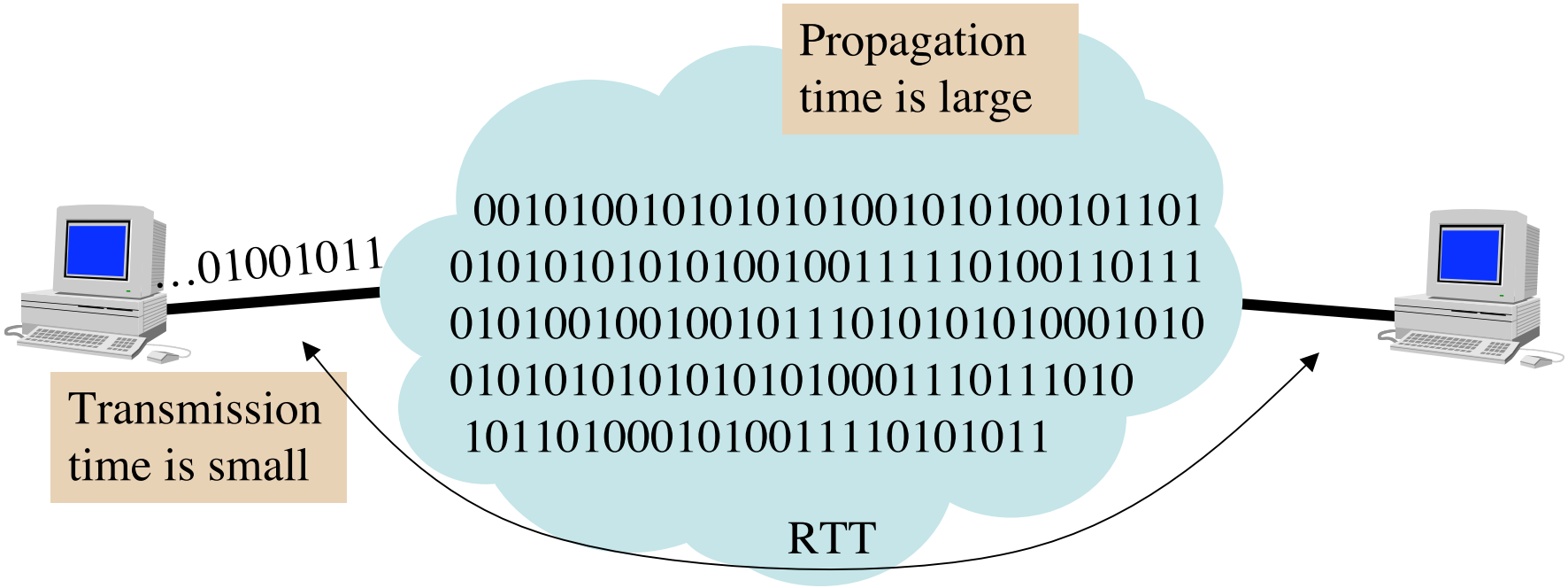
Today, to visualize and explore eight 3D images require 64Gb/s !



Large data transfers require very high bandwidth

Long Fat Networks/Pipes

- High-~~speed~~ capacity network

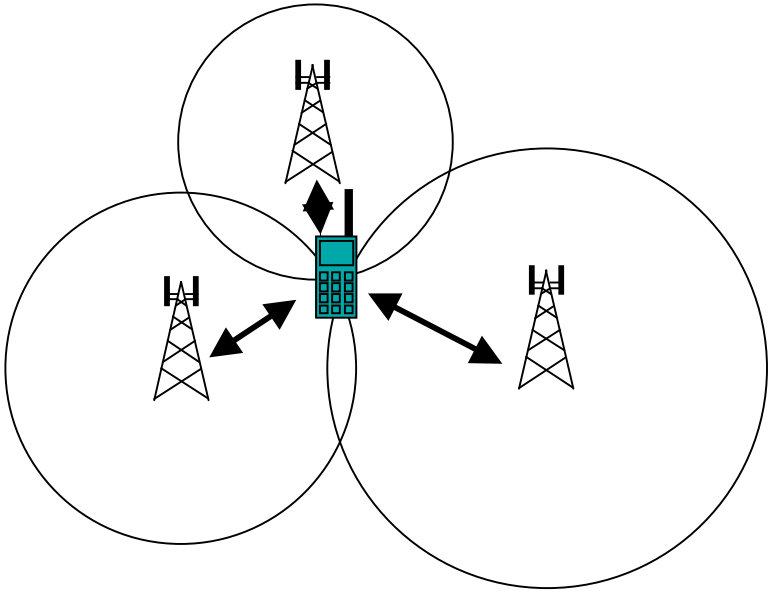


Challenges for HSN

- Transport protocols
  - High utilization
  - Congestion control
  - Fairness
- High performance routers
  - Optical switching
- QoS provisioning and accounting
  - DiffServ
  - MPLS, GMPLS

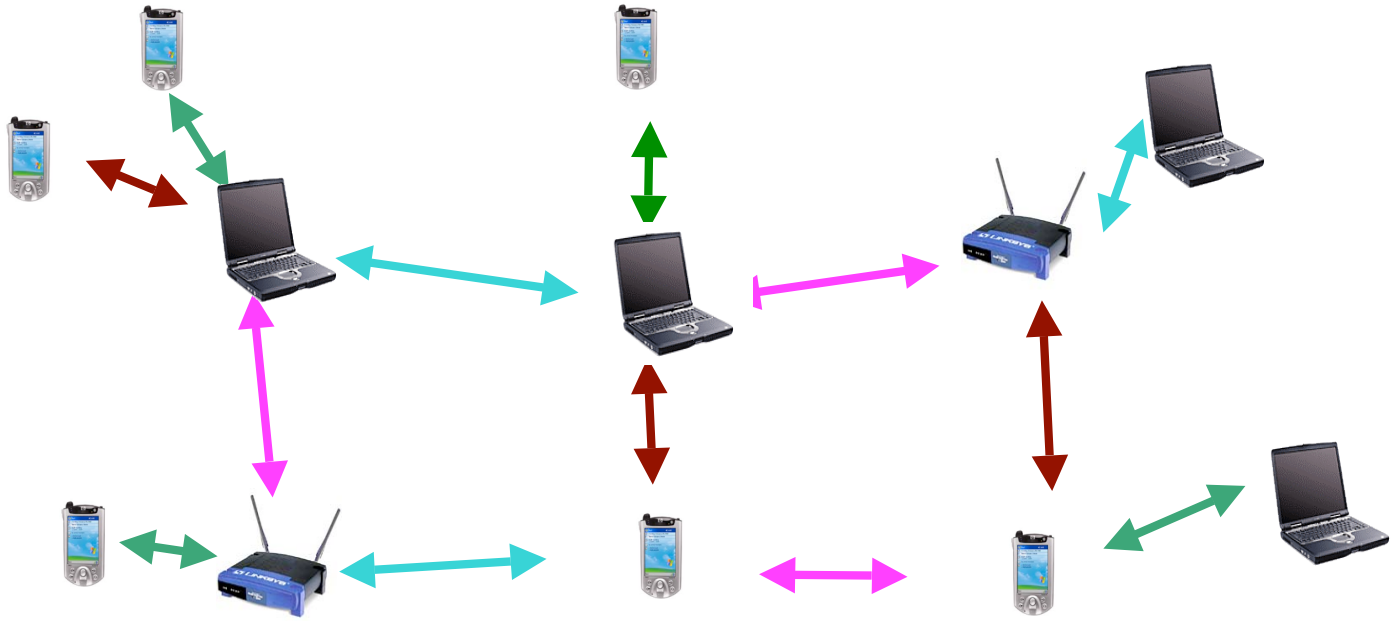
2nd revolution: Wireless Networks

- WiFi, WiMax
- BlueTooth, ZigBee, IrDA…
- GSM, GPRS, EDGE, UMTS, 4G,…



Ad-hoc (wireless) networks

- Mobile ad-hoc networks (MANETS) are networks built on-the-fly, no need for infrastructure



Future will be wireless!

- True for end-users!
- Wireless hot-spots provide ubiquitous access to the Internet
- Lots of high-value added services
  - E-mail and Internet surfing when travelling
  - High-quality multimedia streaming in hospitals, nomadic applications
  - Easy updates of advertising panels
  - Monitoring of elderly people
  - Much more to come!!!

Challenges in wireless

- Physical layer, MIMO
- Medium Access Control
- Routing for ad-hoc networks
- Ubiquity, mobility
- Security
- Congestion control

Now, what's up?

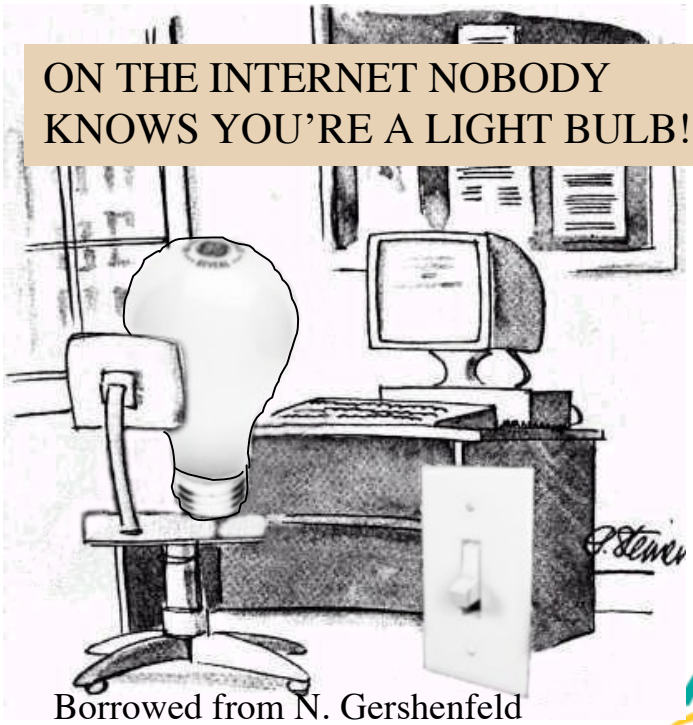
Internet-1

Internet-2

Internet-~~3~~

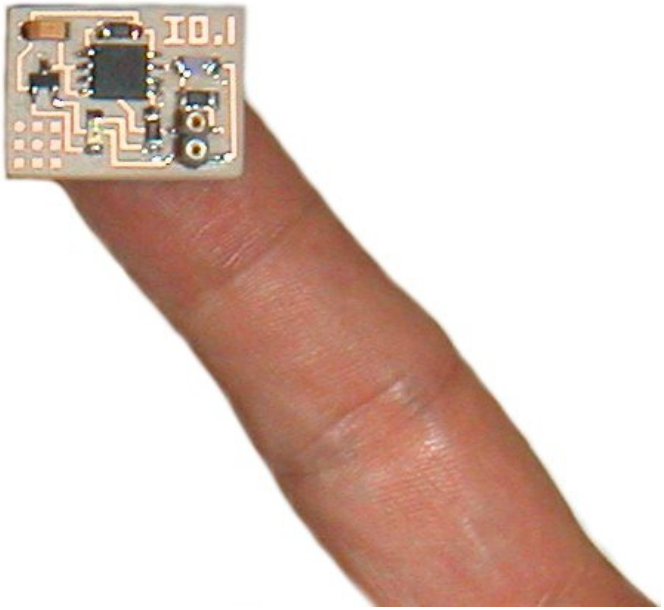
0

Internet-0: the Internet of Things



Borrowed from N. Gershenfeld

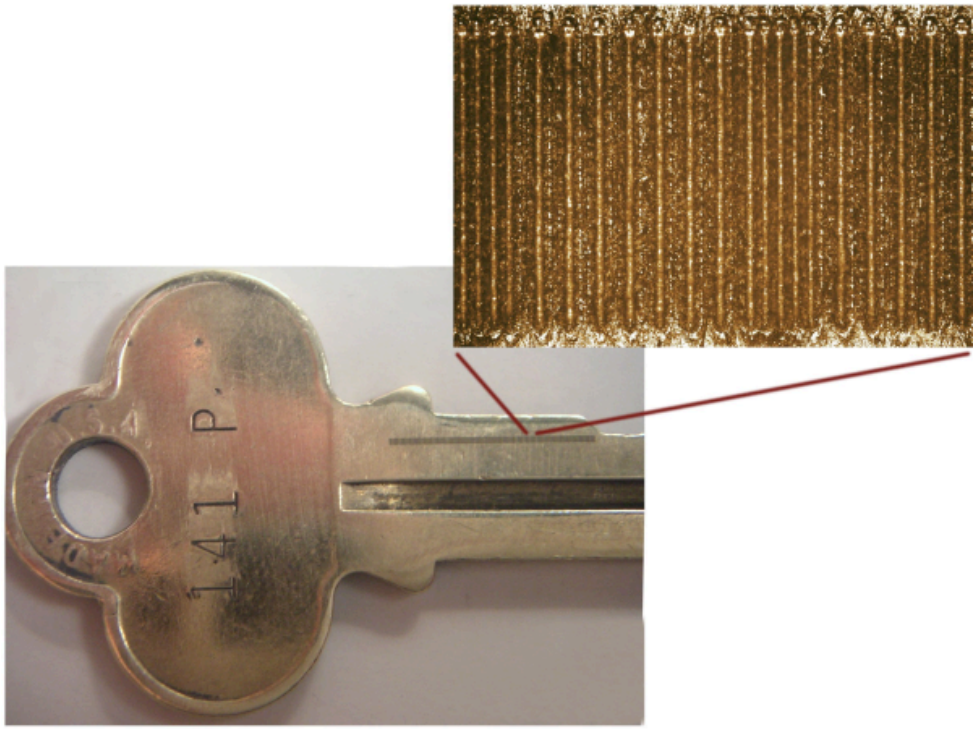
Internet Hosts



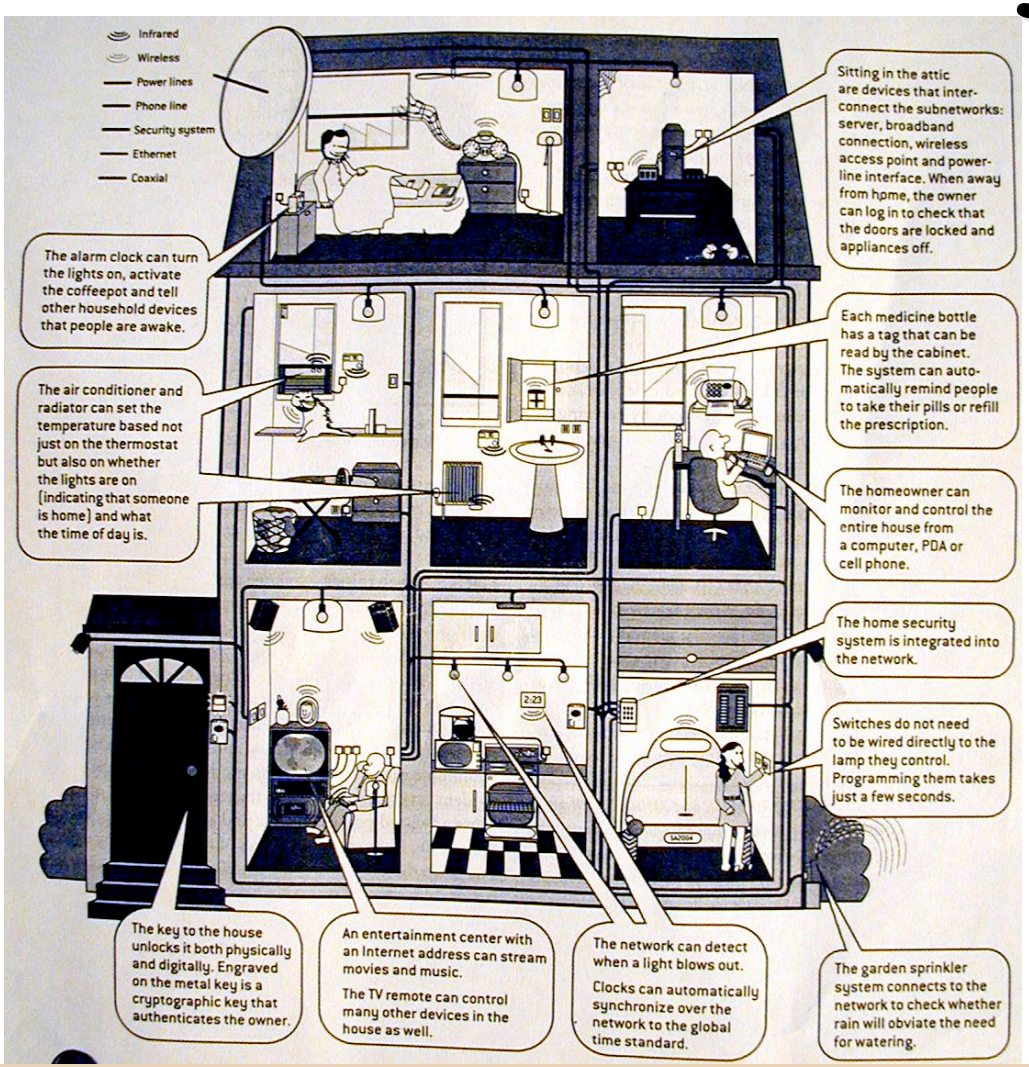
Borrowed from N. Gershenfeld

1974 **2004**

IP on a simple key?



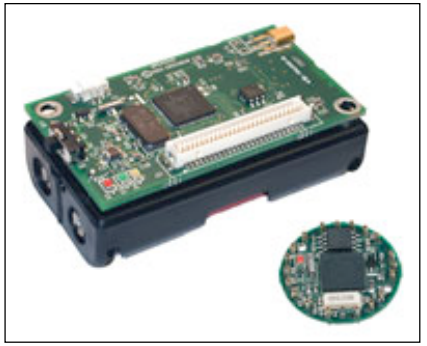
Ambient Networking



From « The Internet of Thing », Scientific American, Oct 2004

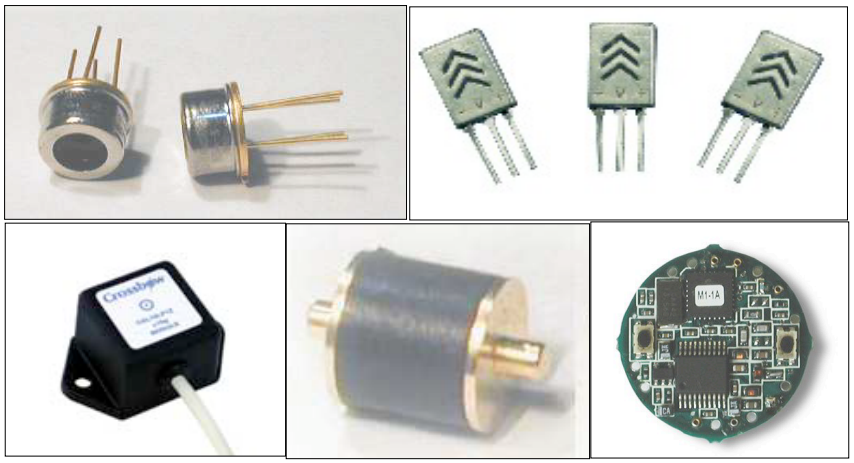
What's missing?

Between the PDA and the RFID tag of Internet-0, is the wireless autonomous sensor



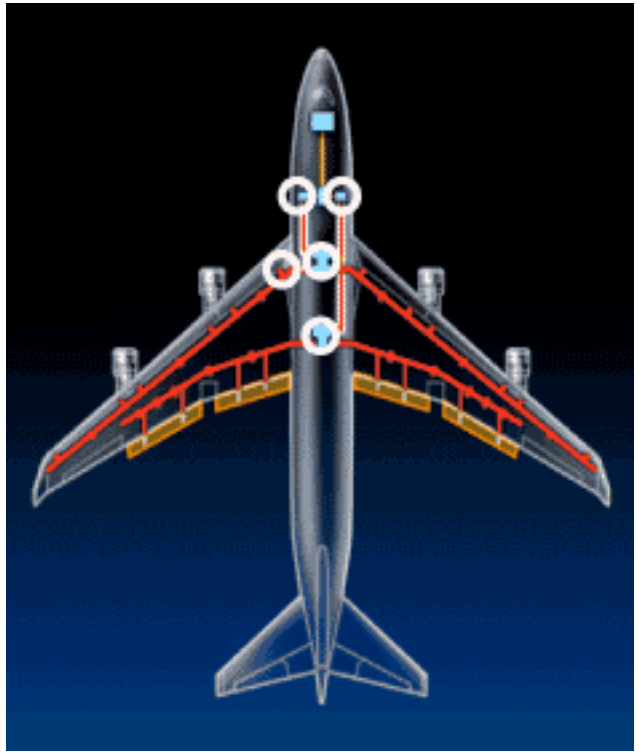
What Is A Sensor Node?

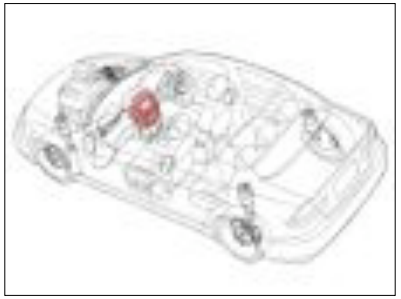
- Sensor nodes could monitor a wide variety of ambient conditions that include the following:
  - temperature,
  - humidity,
  - vehicular movement,
  - lightning condition,
  - pressure,
  - soil makeup,
  - noise levels,



  - the presence or absence of certain kinds of objects,
  - mechanical stress levels on attached objects, and
  - the current characteristics such as speed, direction, and size of an object.
- Sensor nodes can be used for continuous sensing, event detection, event ID, location sensing, etc.

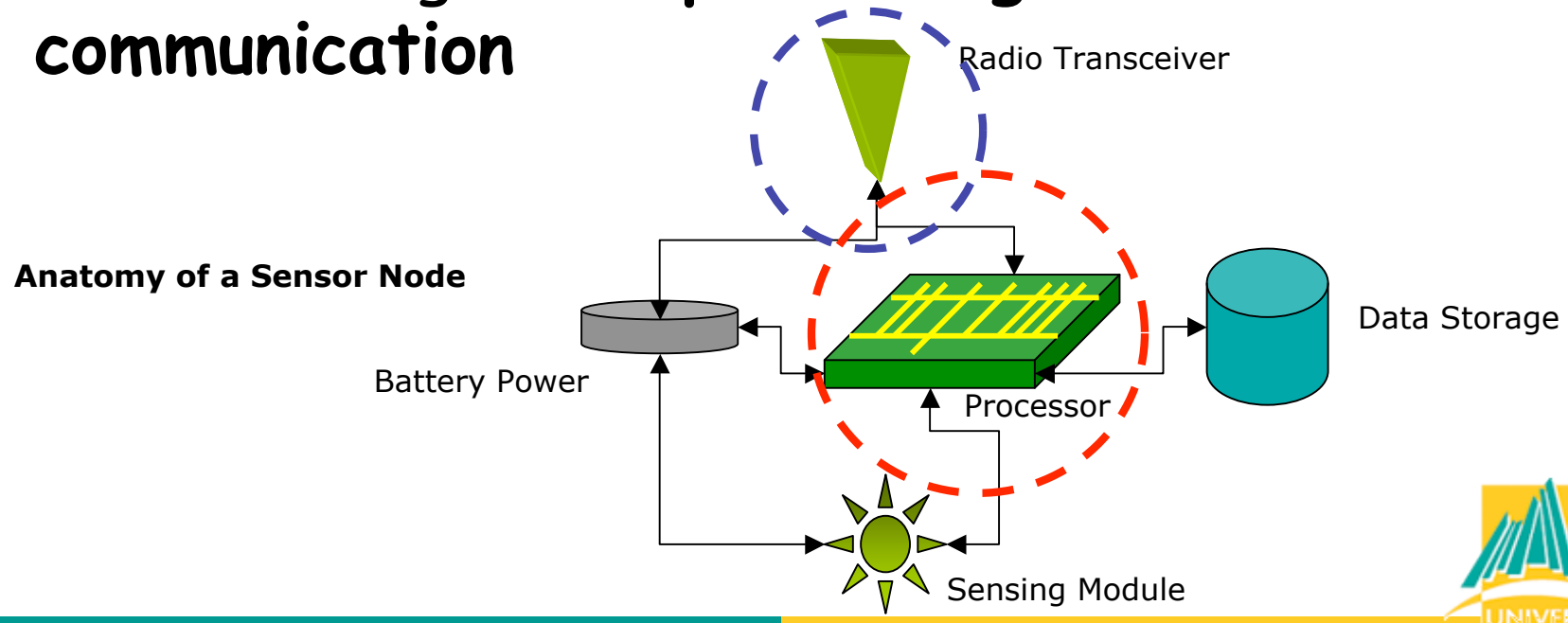
Traditional sensing applications



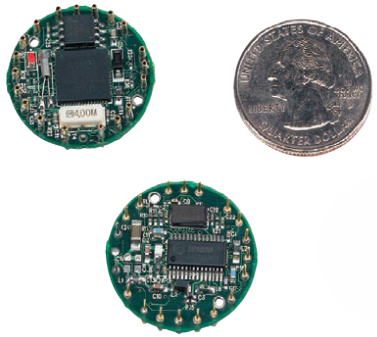


Wireless autonomous sensor

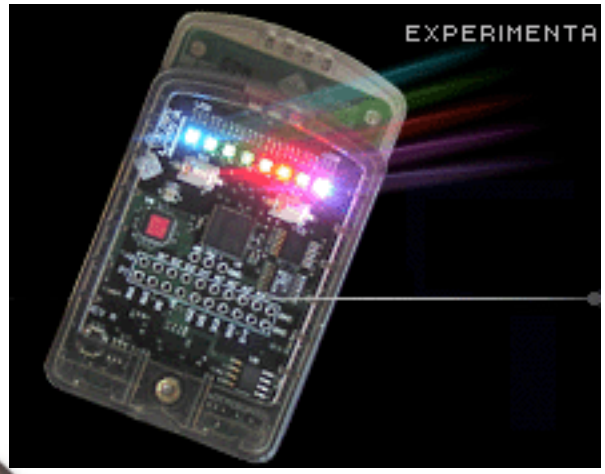
- In general: low cost, low power (the battery may not be replaceable), small size, prone to failure, possibly disposable
- Role: sensing, **data processing**, **communication**



Some wireless sensors



MICA2DOT

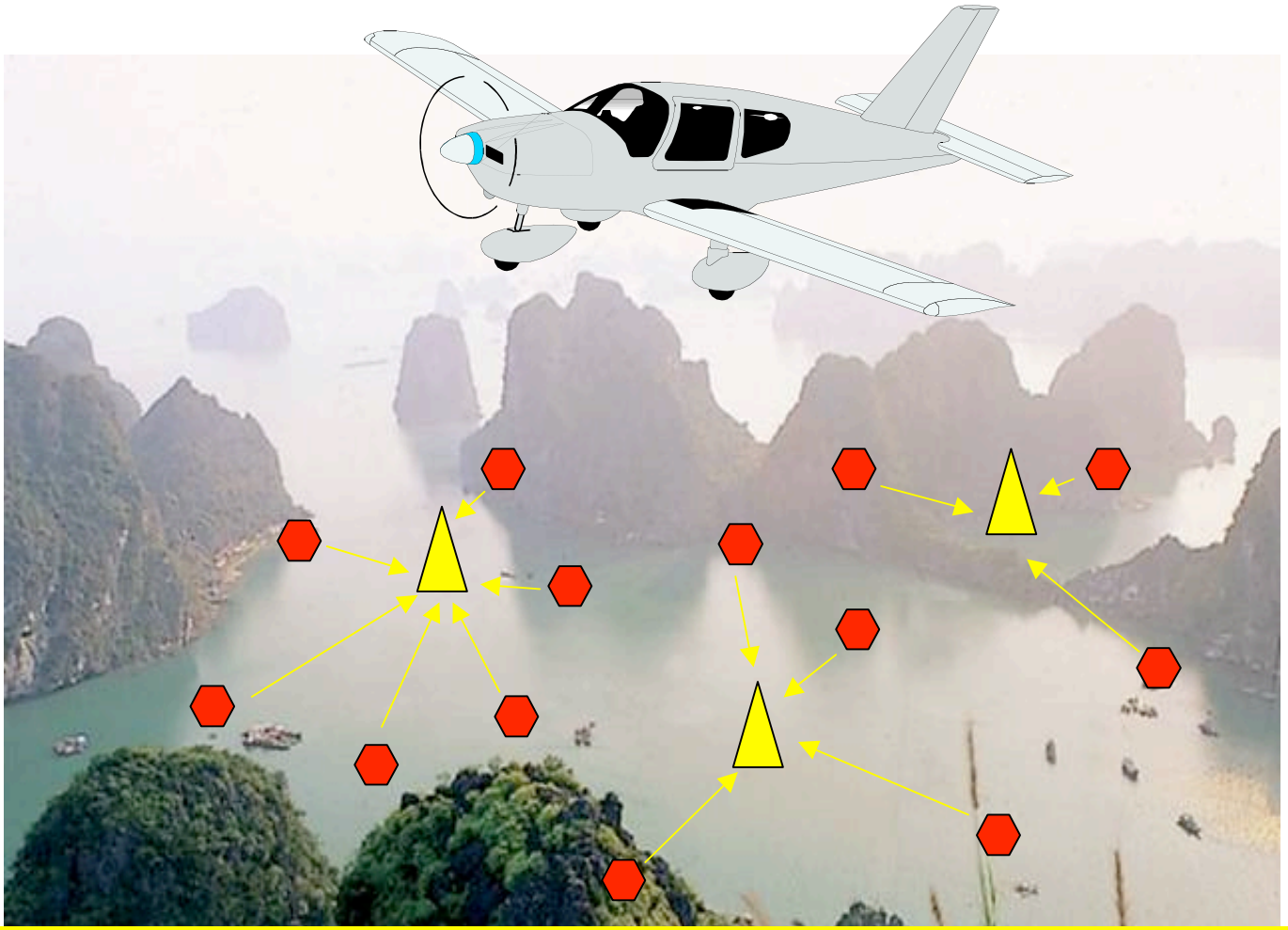


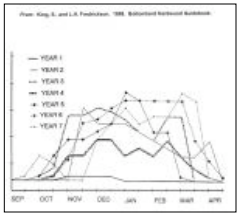
Sensing boards

SUN SPOT

New sensor applications

environmental





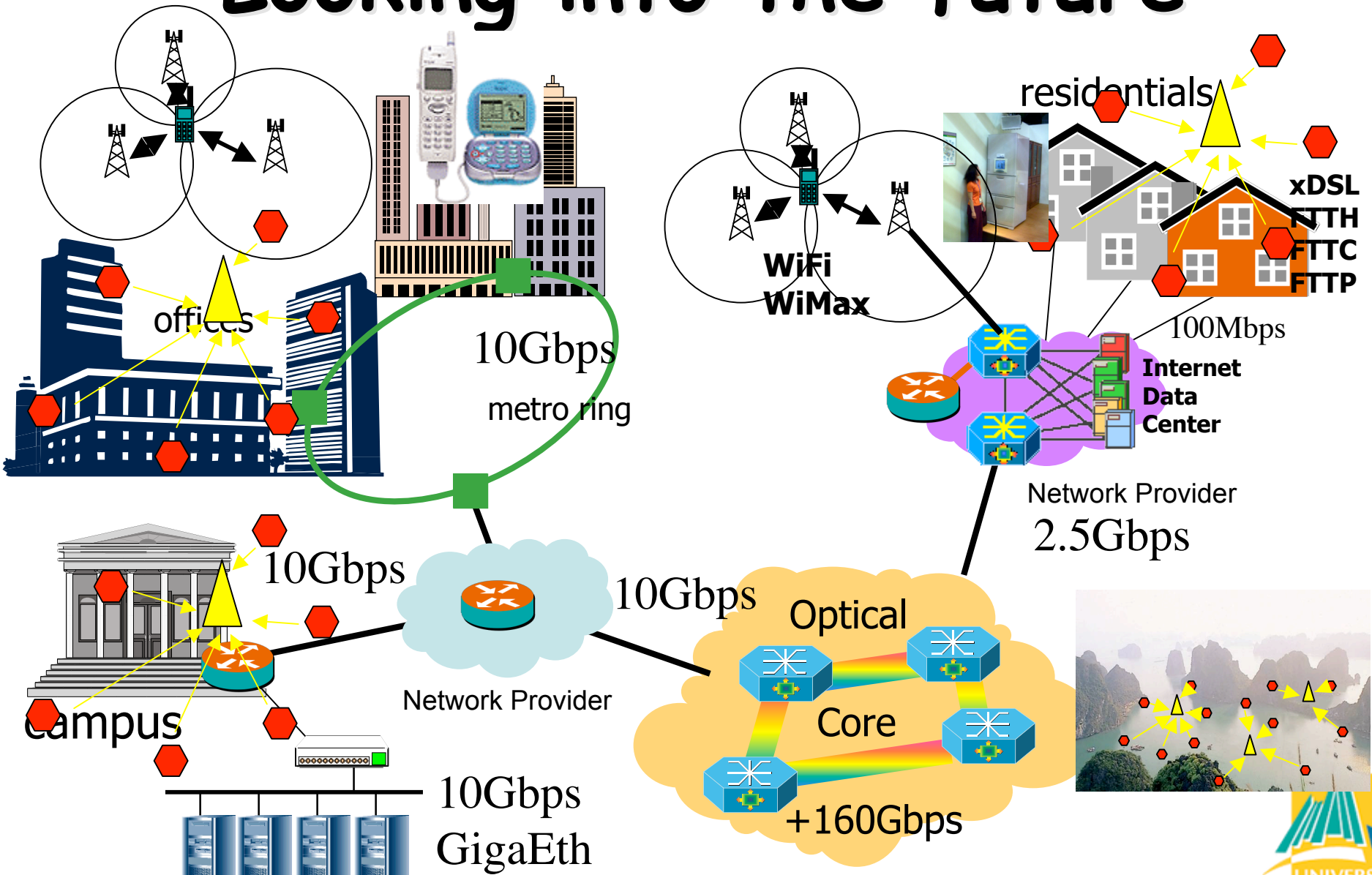
On-the-fly deployment of environmental monitoring's network

Challenges in WSN

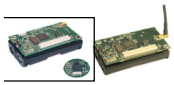
- Adressing, localization
- Multi-path routing
- Self-organizing features
- Software architectures
- Congestion control
- Multimedia WSN
- Integration with IP

POWER MANAGNEMENT

Looking into the future

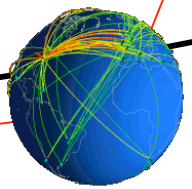


What's wrong?



The Internet has evolved from a wired network for FTP, HTTP and e-mail…

" …the world has changed, the use of the Internet has changed and, fundamentally, the architecture has not evolved to take account of that. " (P. Howell, BT)



Internet

Ubiqu

Mobil

Ad-Hoc

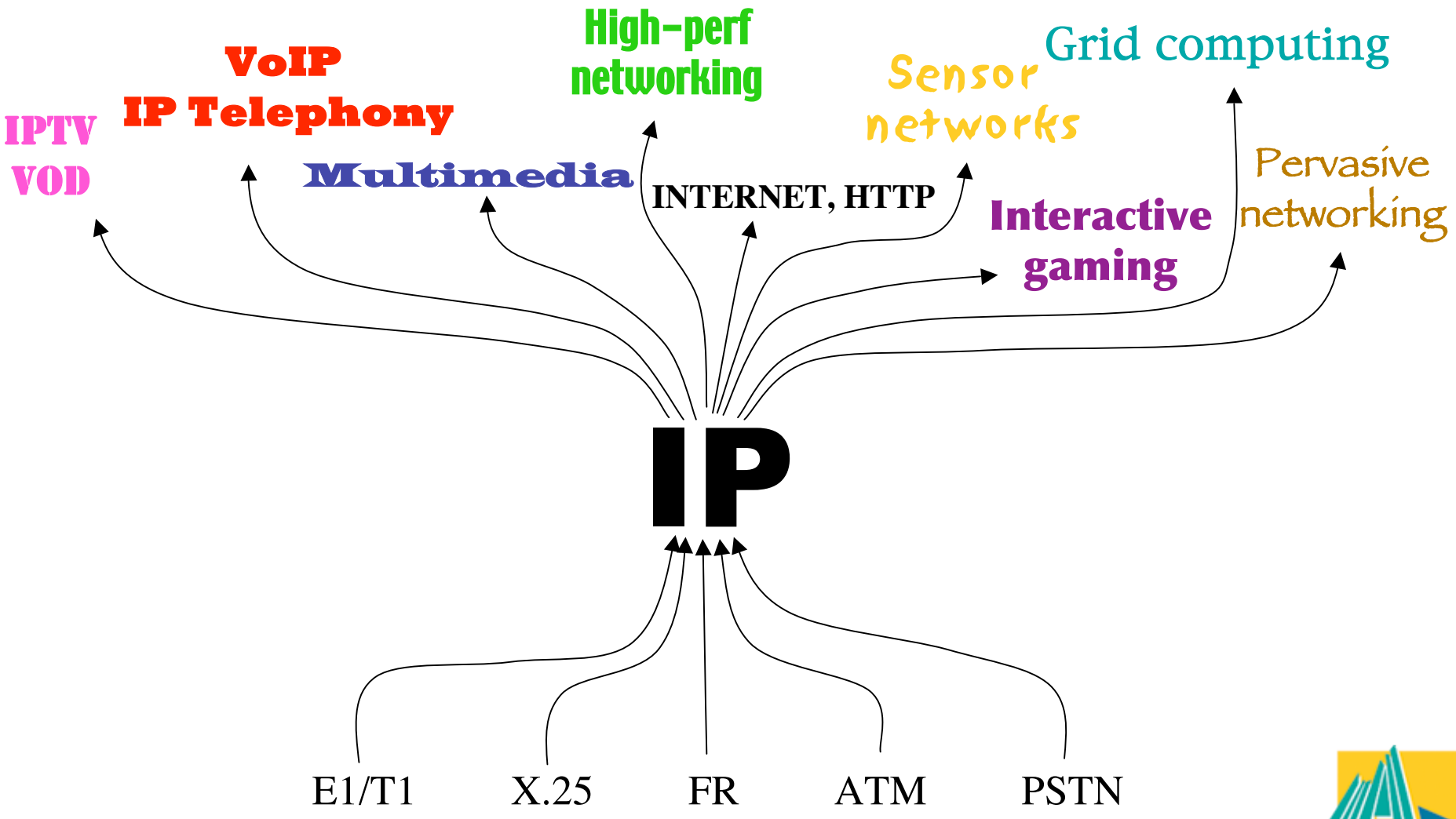
Telephony

MULTIMEDIA

Streaming

… to a fantastic infrastructure with a large variety of communicating devices and high diversity of access and traffic characteristics

The IP-centric view

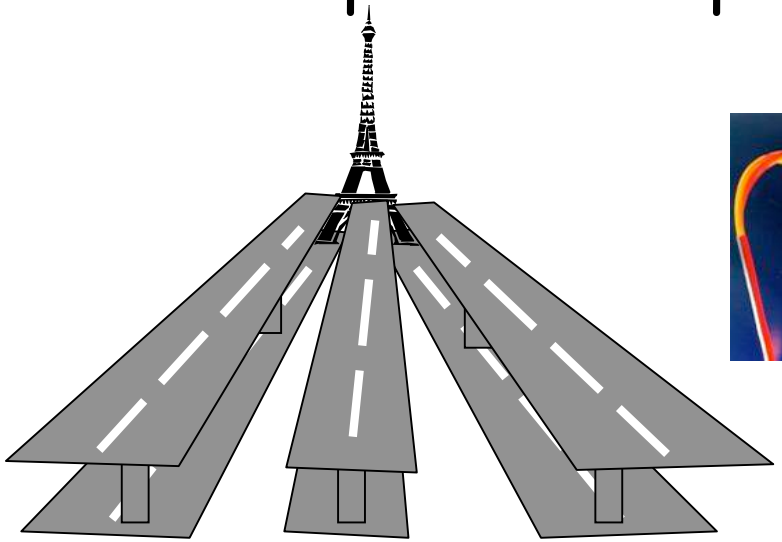


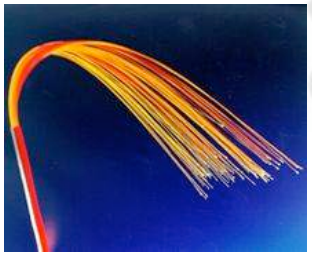
New devices, new needs!

- Rapid deployment of new services, accelerating infrastructure innovation
  - Dynamicity, adaptability
- Manage the high heterogeneity of devices and network accesses
  - Quality of Service
- Customization of services, application-oriented processing features

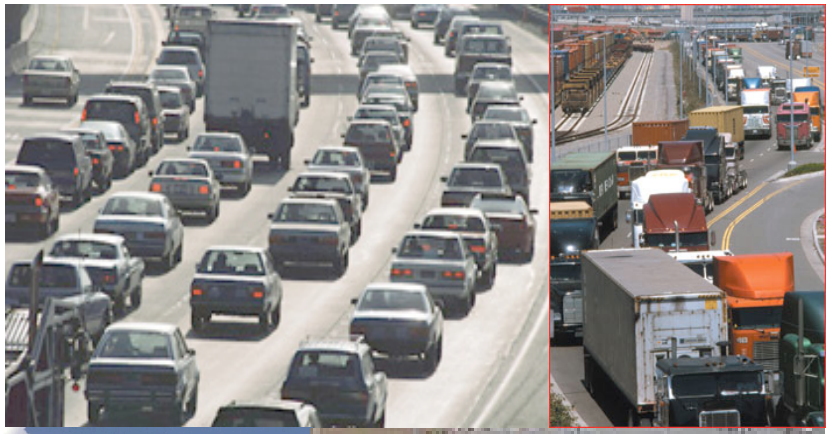
Overprovisioning in the core

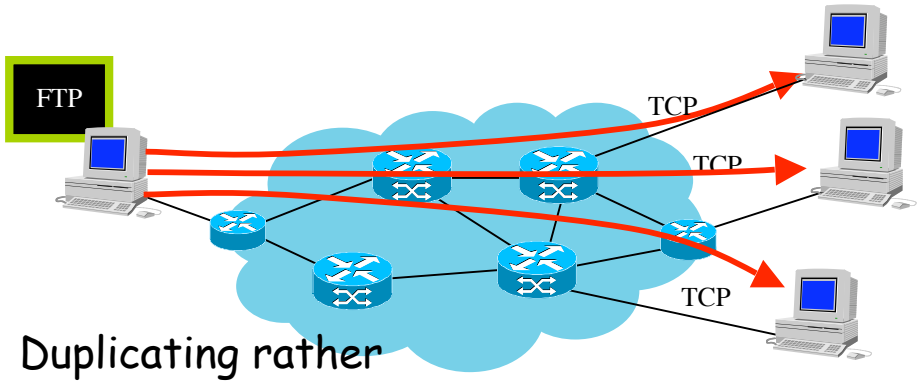
- Most operators are overprovisioning bandwidth with DWDM fibers
- 10Gbps, 40Gbps, 160 GBps, 320 Gbps!
- Overprovisioning is a short-term solution that prevents optimizations



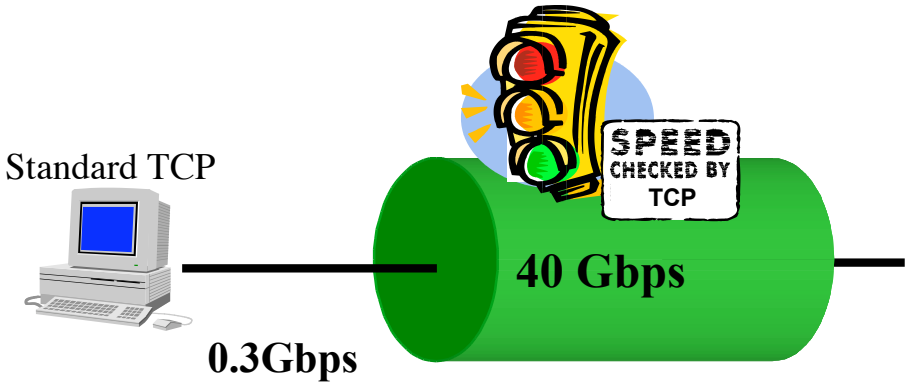


Overprovisioning: a huge waste of resources





Duplicating rather than optimizing!

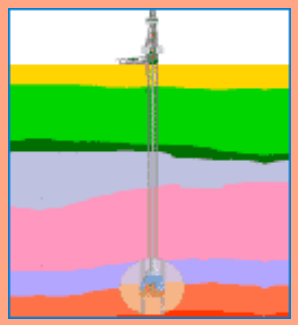


Transferring a 1GB file with a standard TCP stack needs minutes even with a 40Gbps (how much in $?) link!

Is overprovisioning harmful?

- NO: overprovisioning is not very costly. Adding new wa… …ppy and quick re…
- YES: w… …utions are not … much on old t… …ible (c.f. IPv6, T…





Each new oilfield discovery delays research and development of alternative energies

Net Neutrality or Not?

- NN or NNN? That's the question!
- NN = dumb network!
- Internet's success is in a large part debtful to what's called Net Neutrality (IP neutrality)
- So is the evolution of our society!

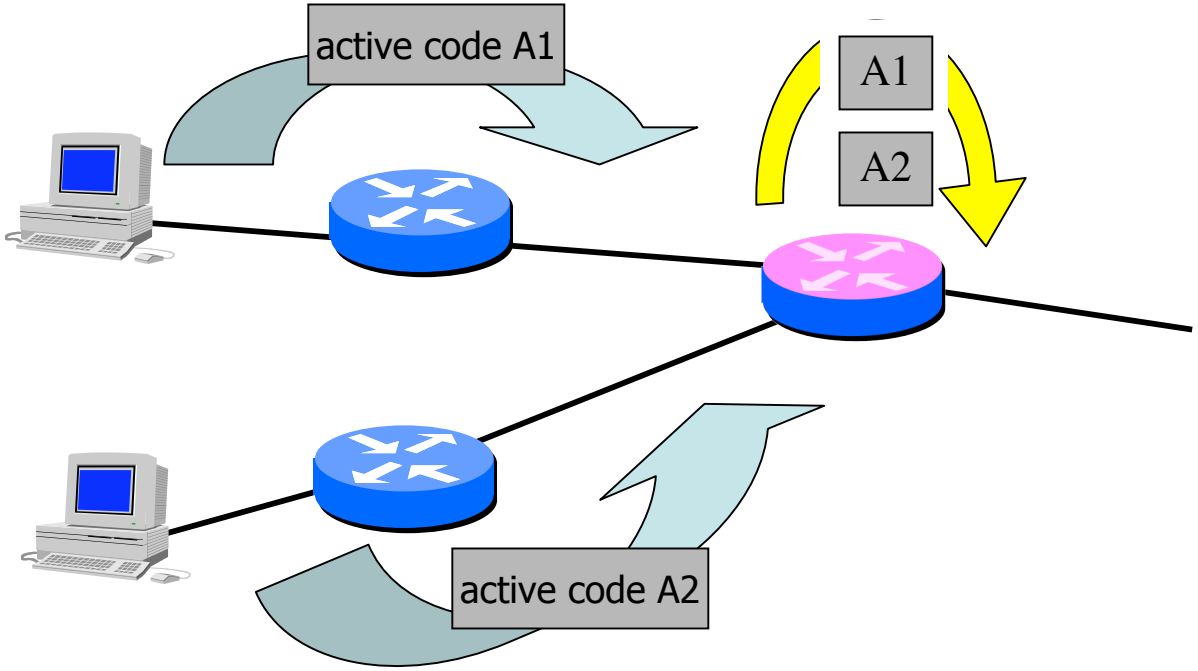
Can we afford to continue blind, unconcious development?

Internet-1 & Internet-2

- The network is a transport network, only a transport network!
- Processing inside the network is limited to tasks for performing the transport itself
- End-to-end is the main way of operation
- Links are getting faster, host are getting more and more powerful

In-network processing

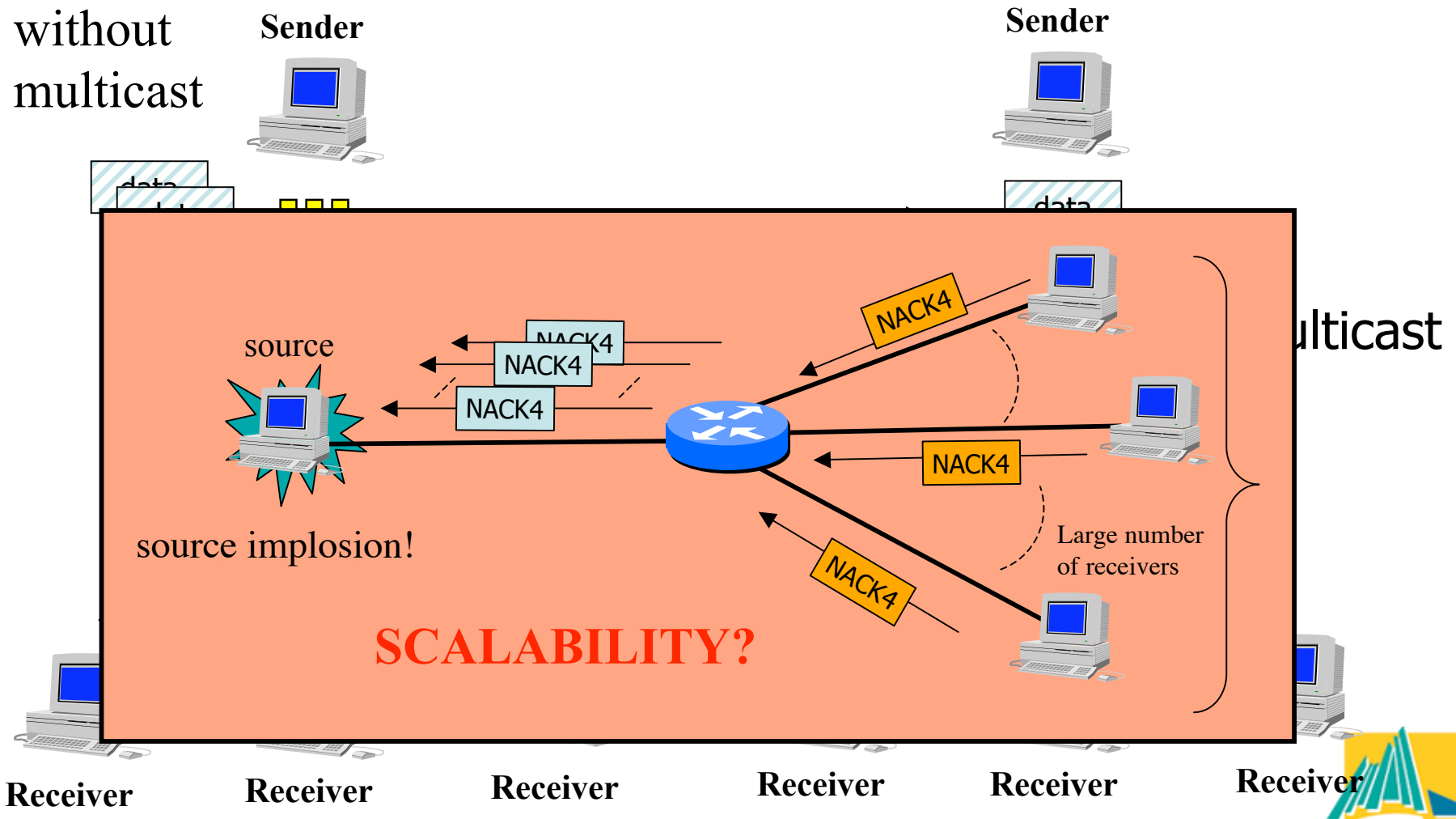
- Network element (routers) can perform application-oriented tasks on incoming packets



Programmable routers?

- Programmable nodes/routers
- Customized computations on packets
- Standardized execution environment and programming interface
- No killer applications, only a different way to offer high-value services, in an elegant manner
- Adds extra processing cost but improves global peformances

Example: Multicast



Feedback aggregation

- ACK aggregation
- NACK suppression

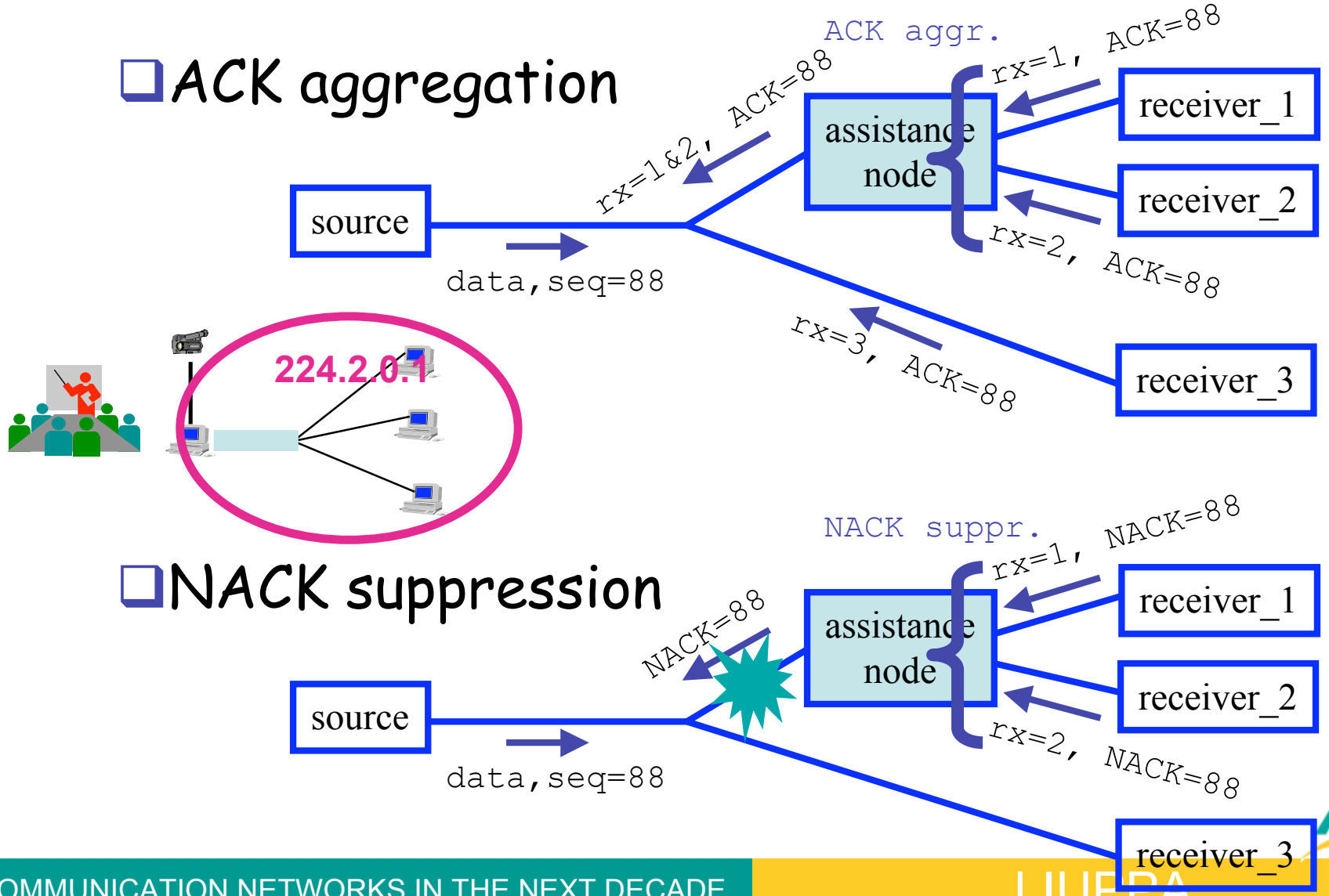
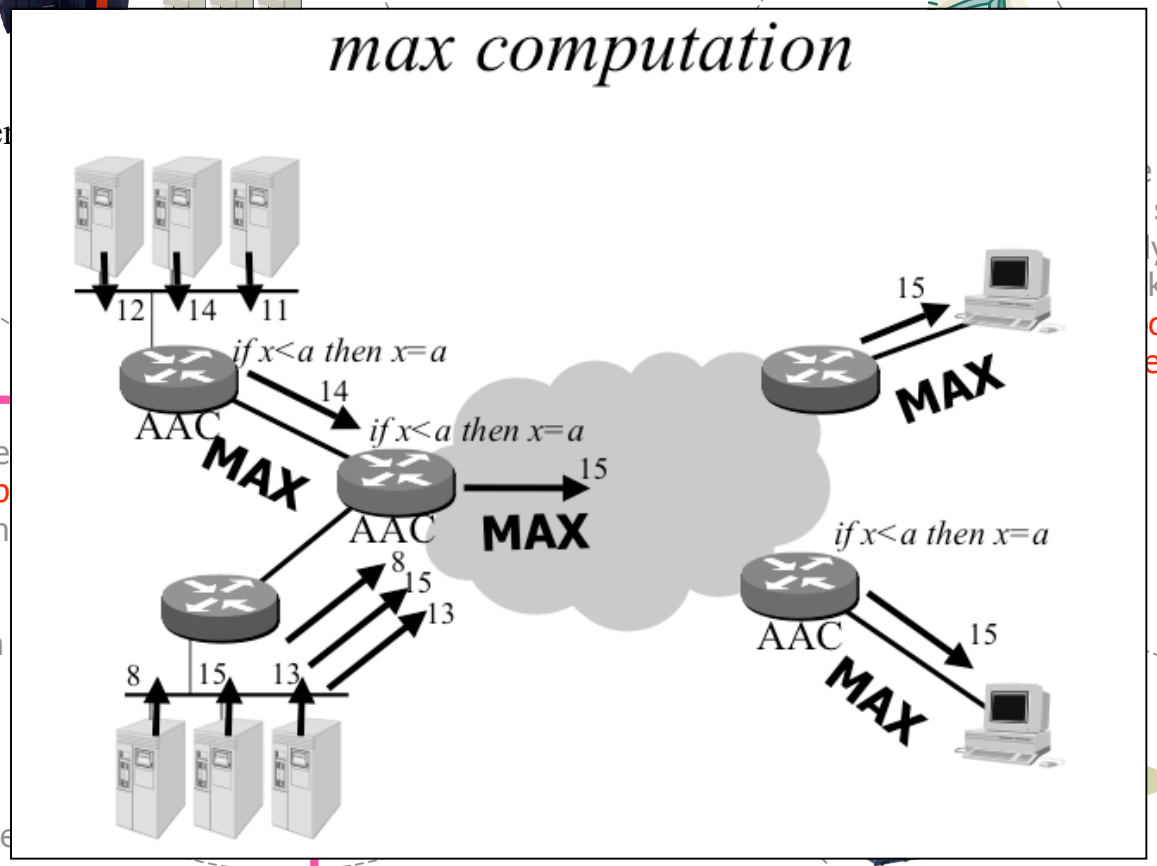


Illustration on a grid



Computing center

AAC associated to source can perform y processing on kets such as casting and loss ection services.

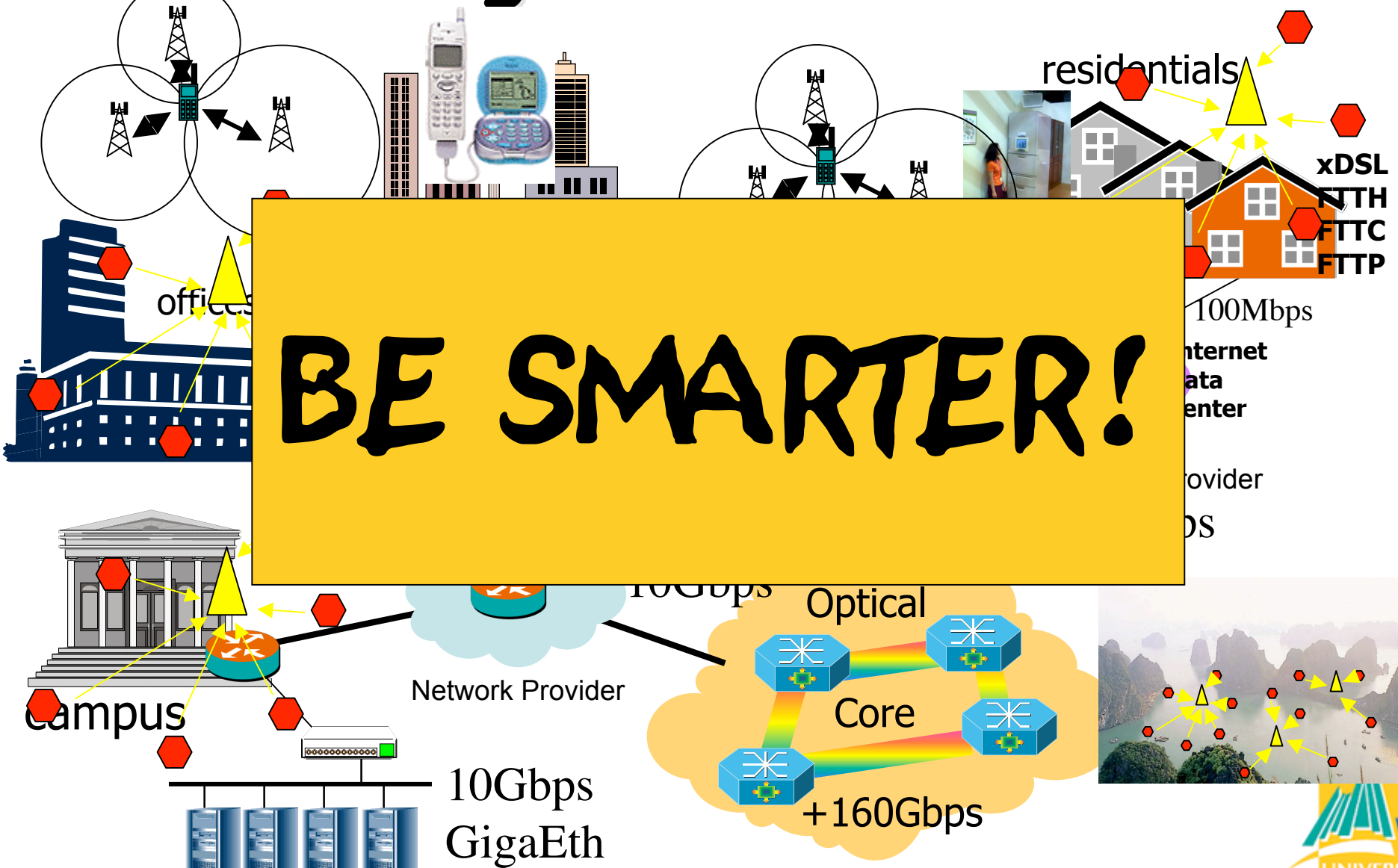
Any receiver can be designated as a rep for a loss packet.Th election service is performed by the upstream AAC on a per-packet basis. Having dynamic repliers allows for more scalability as caching within route is not required.

An AAC associated to a tail link performs NACK aggregation, subcasting and the election on a per-packet basis of the replier.

Computing center

AAC: ***application-aware component***

Looking into the future



Can bring high benefits for

- Routing
  - Provide multi-path routing, QoS-based routing
- Security
  - Detect DDoS
- Congestion control
  - Enhance responsiveness, utilization of HS links
- Real-time & interactive applications
  - Filtering, on-the-fly compression
- Network management

A day in the life of a computer scientist is 2012