Why the Internet?

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Where we've come from...

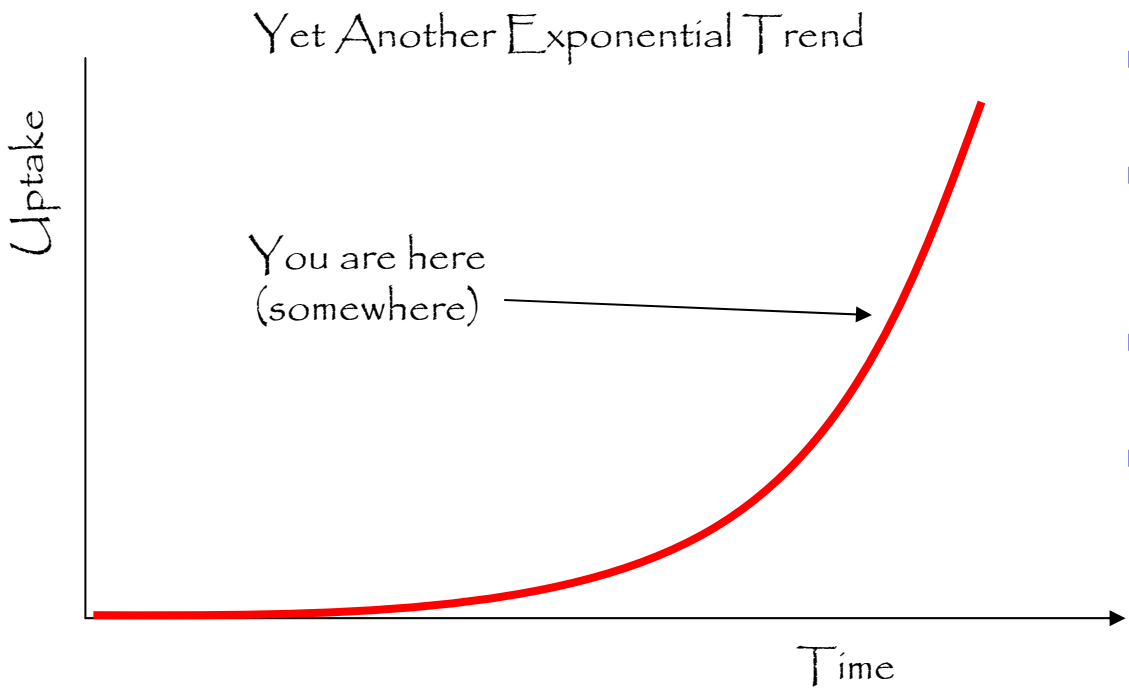
- A research experiment, started in the 60's looking at how to build a highly reliable network using less than highly reliable components
- A global academic and research experiment, started in the mid-80's looking at the use of data networks as a computer support tool
- An experiment in the early 90's looking at information exchange models and their use
- Mass deployment.....

Predictions come in many forms…

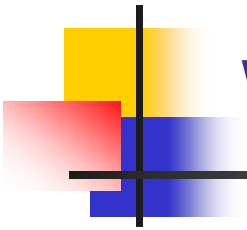
“Man will one day travel faster
than a horse can run…”

René Descartes, 1685

The Internet Today



- Still in the mode of rapid uptake with disruptive external effects on related activities
- No visible sign of market saturation
- Continual expansion into new services and markets
- No fixed service model
- Changing supply models and supplier industries



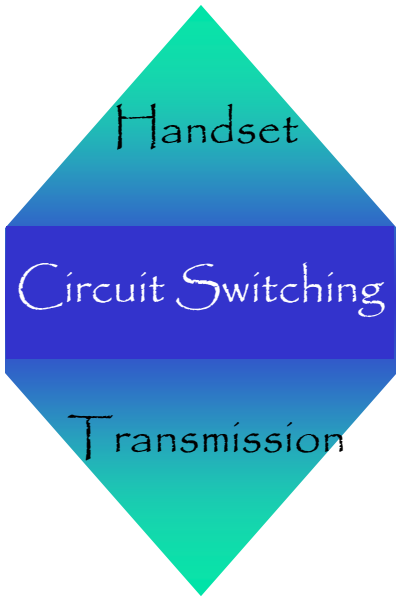
Why the Internet?

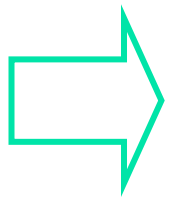
- Its NOT the protocol
  - Although the protocol is stunning in its elegance and simplicity
- Its NOT the Web
  - Although the web is cute
- Its a revolutionary marriage of computing and digital communications technologies which exploits the strengths of both

The Internet IS Different

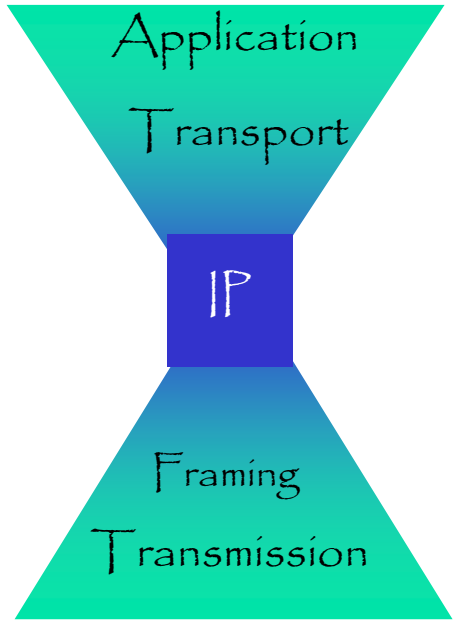
- A radically new network model:

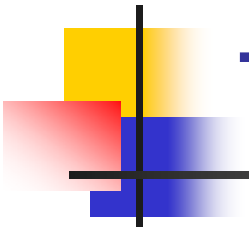
Voice over circuits
Circuits over bitstreams





Anything over IP
IP over anything

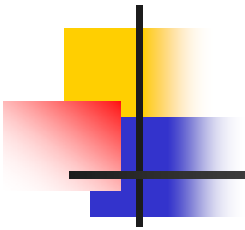




The Internet is simple

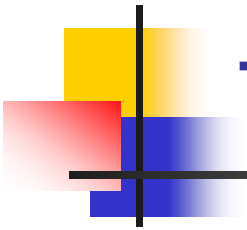
- The Internet is simply a collection of packet switches linked together by transmission elements:
  - Packets can be queued
  - Packets can be lost
  - There is no end-to-end time coupling and there is no end-to-end reliability coupling.
  - Every packet is a new adventure!

- This allows an Internet network to use basic and cheap transmission elements and basic and cheap packet switches.



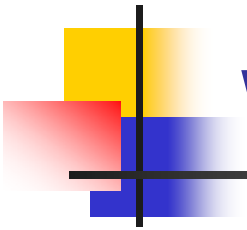
Host Software is complex

- In IP, functionality is pushed right out of the Network to the Host at the Edge
  - The web is not INSIDE the network – its on the EDGE
  - Your web browser runs on your computer
  - The web server runs on the computer on the other end
  - The Internet simply allows the two computers to conduct the conversation



The Internet Model

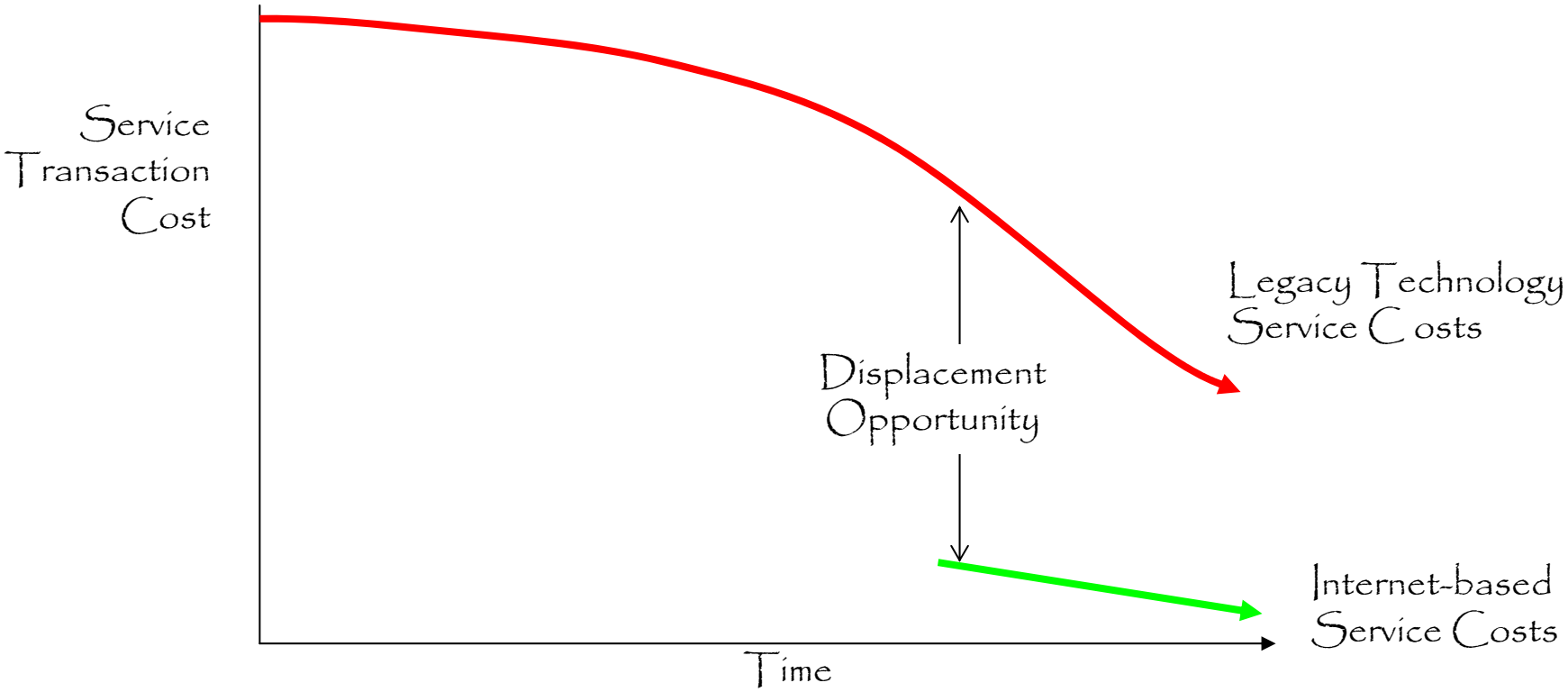
- Application functionality shifts from the Network to the edge Device:
  - Dumb Network
  - Smart Devices



WHY the Internet?

- **Cheap** to access and exploit
- **Fast** in terms of protocol efficiency
- **Adequate** service model for a large set of potential services

The Disruptive View of the Internet



The Disruptive View of the Internet

- **Adaptable services** quickly migrate to use a cheaper cost base
  - Personal and Group Messaging
  - Data transfer
  - Information Services
- **Other services** migrate based on exposure of opportunity
  - Commerce transactions (X.25 to IP)
  - Voice (PSTN to IP)
  - Music distribution (plastic to IP)
  - Video distribution (tape to IP)
- Continually decreasing unit costs and increasing penetration of access devices work together to continually expose new applications and new markets for the Internet

Internet Drivers

- Expansion is continuing at an exponential growth rate.

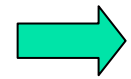
- Growth of access channels:
  - Corporate Connections
  - Office Suites
  - Residences
  - And next …. Public Spaces

- Use Drivers
  - Information
  - Commerce
  - Entertainment

    Never underestimate entertainment!

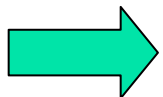
Futures for the Internet

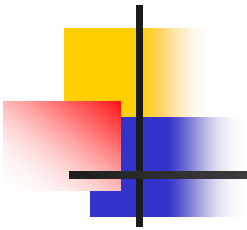
- Same basic model:
  - dumb network, smart devices
  - Packet-based model of network sharing
  - Packet reordering, loss and jitter to remain
- Same drivers:
  - Continued growth in uses
  - Continued broadening of the utility model through growth in overlay applications
  - Continued unit price drop in service costs for Internet-based services



Futures for the Internet – Coping with Scale

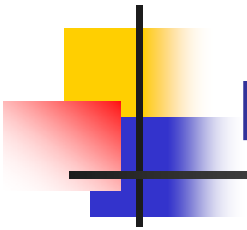
- Billions of addressable devices
- Either: back to the fragmented multi-protocol world:
  - ‘Walled garden’ domains of rich functionality
  - Inter-domain basic functions undertaken with application-level boundary gateways
- Or: we get serious about coherency of communications
  - Reduction of use of network boundary-ware in favour of end-to-end architectures that scale to billions of interoperable devices





IP Carriage Architectures

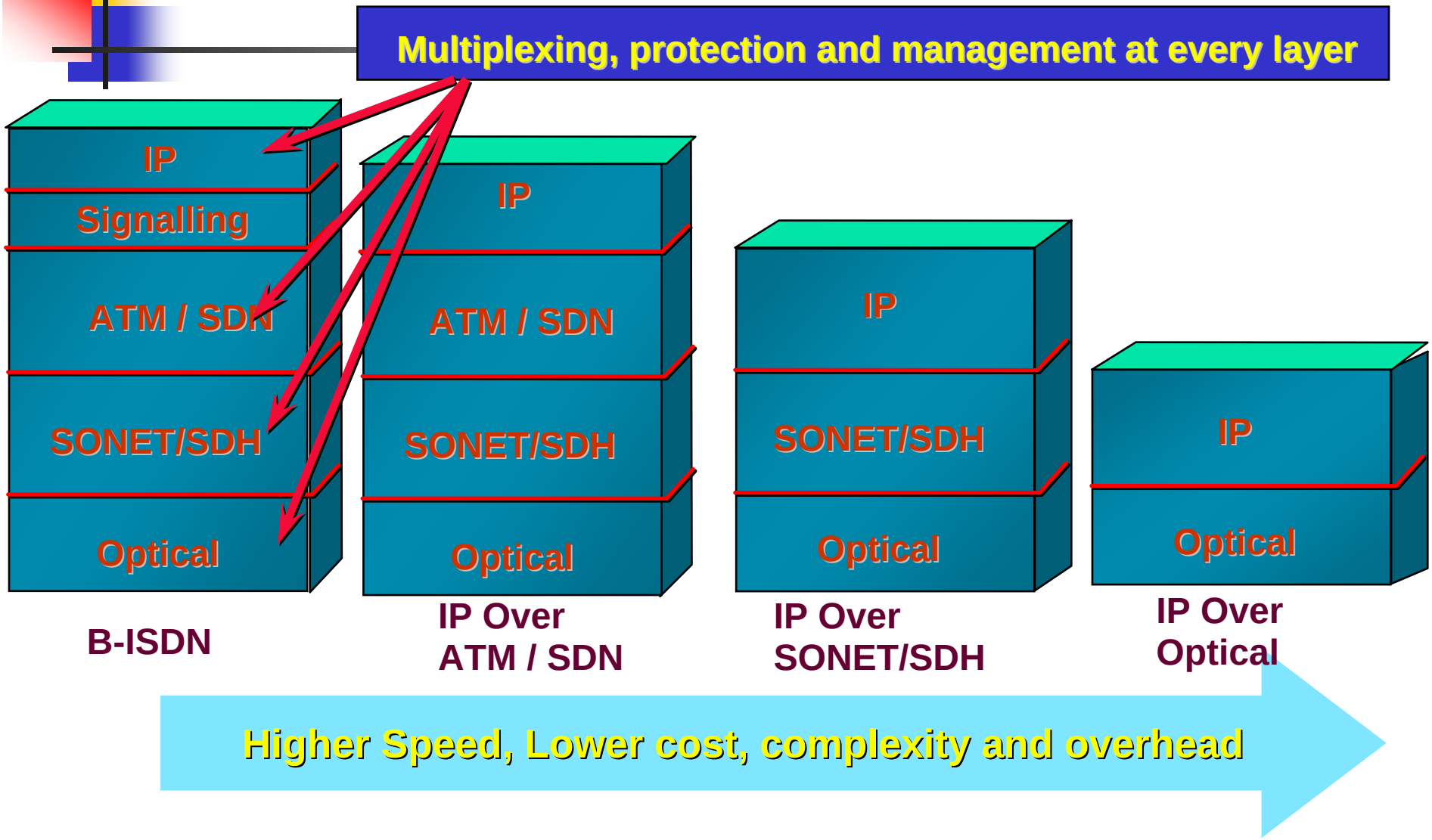
- Issues in designing an efficient high speed IP backbone network



Engineering Internet Backbone Networks

- Data Networks were originally designed as overlays on the PSTN network
- As the Internet evolved its demands for carriage capacity have increased more than one million-fold
  - This massive increase in volume requires rethinking how to efficiently build data networks
- This has lead to engineering data networks without an underlying PSTN
  - Such IP trunk networks are very recent developments to the carrier engineering domain

The Evolution of the IP Transport Stack



Carriage Networks and IP packets

- Each speed shift places greater functionality into the IP packet header and requires fewer services from the carriage system
- Networks need to get **faster**, not **smarter**

NETWORK	→	**PACKET**
real time bit streams	→	**asynchronous data packet flows**
network data clock	→	**per-packet preamble data clock**
end-to-end circuits	→	**address headers and destination routing**
fixed resource segmentation	→	**variable resource segmentation**
network capacity management	→	**adaptive dynamic utilization**
single service platform	→	**multi-service payloads**

Bandwidth Supply and Demand

- Fibre installation is now exceeding Mach 4 per hour for single optical strand equivalent
- *Dense Wave Division Multiplexing* is lifting per-strand optical capacity
  - from 2.5Gbps to 3.2Tbps (320 wavelengths, each of 10Gbps per lambda) per optical strand

"Raw" Bandwidth will get cheaper per unit

Likely trend from demand pull to massive overhang of excess supply in the wholesale trunk carriage market

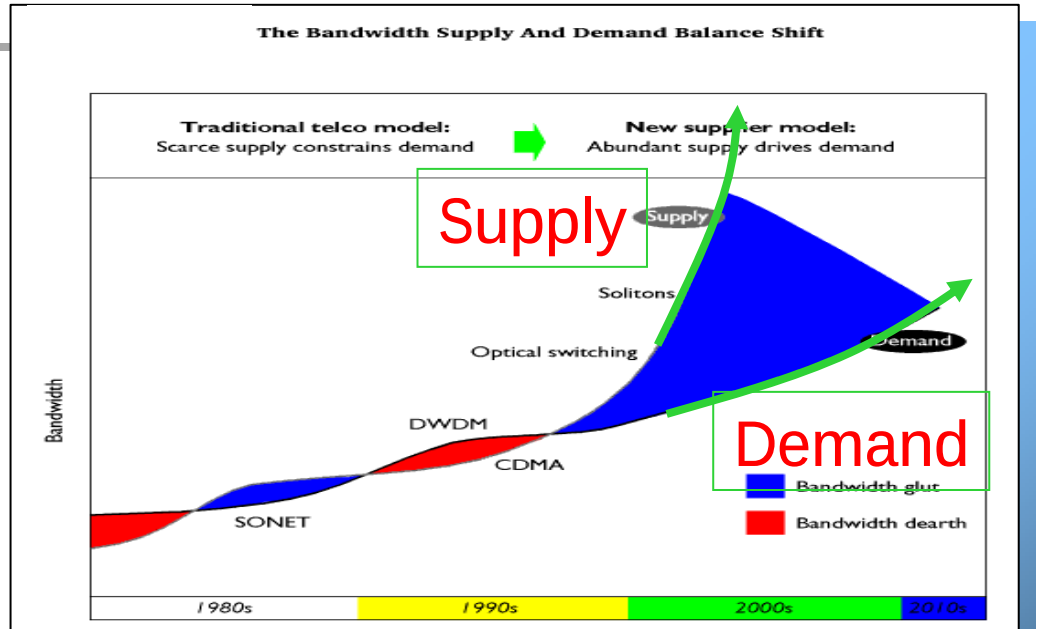
Bandwidth Supply and Demand

"An emerging combination of new technologies, and new service suppliers will create a long-lasting abundance of bandwidth permanently altering the supply-demand equation."

Forrester Dec 97.

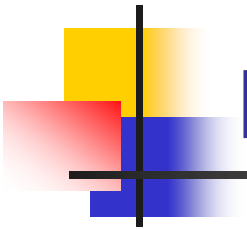
"The potential capacity between major [European] cities will rise one-thousand fold over the next three years"

Yankee Group Aug 98.



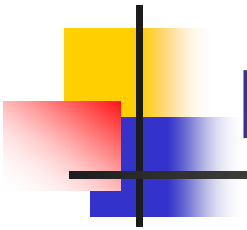
Technology	Description	Time frame
SONET	▪ Synchronous Optical Network ▪ Increases fiber speed from 45 Mbps to 10 Gbps	late 1980s
CDMA	▪ Code Division Multiple Access ▪ Expands wireless capacity tenfold	mid 1990s
DWDM	▪ Dense Wavelength Division Multiplexing ▪ Divides fiber into multiple wavelengths ▪ Increases fiber capacity to 100 Gbps and beyond	late 1990s
Optical switching	▪ Speeds up switching and transport by removing electro-optical conversions	early 2000s
Solitons	▪ Reduce cost of long-distance transport by removing fiber amplifiers	late 2000s

Source: Forrester Research, Inc.



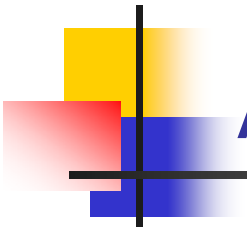
Faster Core IP Networks

- From Silicon switching to Photon switching
  - Reduce the number of optical / electrical conversions in order to increase network capacity to gigabit long-haul trunk networks
- The next generation optical switched backbone
  - Gigabit to Terabit network systems using multi-wavelength optical systems
  - Single hop routing to multi-hop optical Traffic-Engineering control planes



Futures: Faster Networks

- From **kilobits**
  - Modem-based overlay access
  - *Mail, web*
- To **megabits**
  - ADSL over copper
  - HFC IP over cable
  - Broadband Satellite
  - *Mail, web, voice, streaming video*
- Ultimately, to **gigabits**
  - fibre last-mile deployments
  - *Mail, web, voice, video, virtual reality, conferencing…..*



An Abundant Network Will Enable…

- Bandwidth-hungry applications
  - Electronic “mail order” shopping and other commerce
  - music delivery
  - video delivery
  - Remote Sensing and Imageing apps
  - Wide-scale teleconferencing
    - Remote learning, remote presence
  - Your idea here…
- Massive use in small dedicated applications
  - Online appliances with embedded communications functions

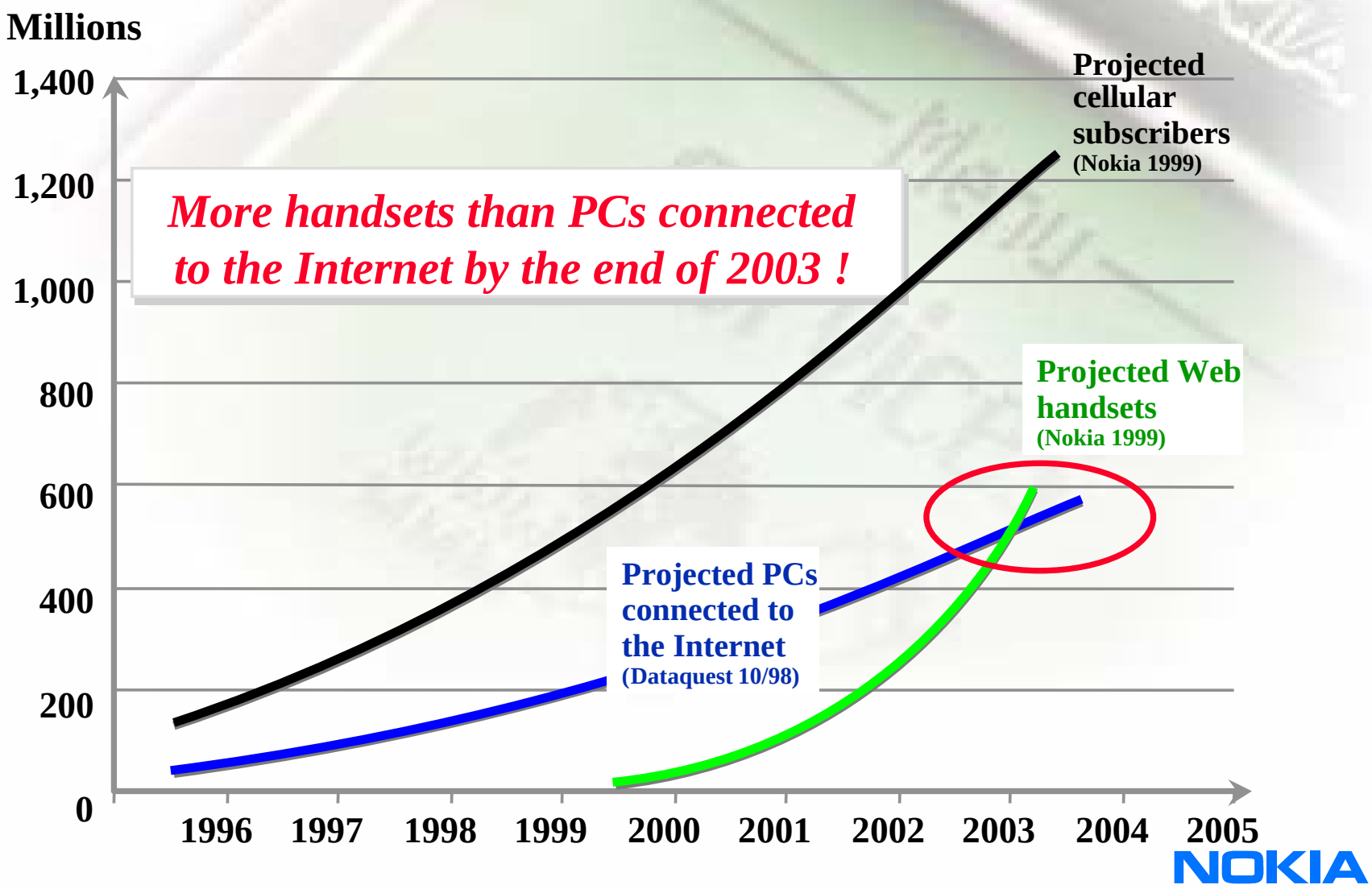
IP Devices are changing too....

- PCs and the fixed network
- Laptops with wireless LANs
- PDAs and Phones
- Appliances with embedded IP

Mobility is coming now

Appliances will come next

Mobile Internet Outlook



NOKIA

Big issues in the Big Internet

1: Content

- The role of content in an online world

2: Content

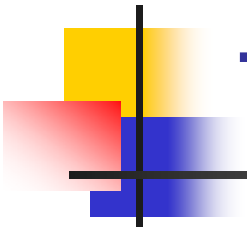
- The Content economy

3: Content

- Intellectual property and content

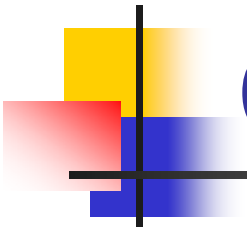
The Internet Content Model

- Finding information is not the problem
  - Finding too much information of dubious relevance and dubious authority is the continuing problem!
- An environment of Content Abundance



The Content Model

- Internet-based Content Abundance
  - Information publication will continue to be driven into cheaper and easier to use models
  - Single point content publication architectures will fade to be replaced by reference-driven distributed cache models
  - A content URL becomes in effect an index used to query a cache, not a lookup performed at a nominated unique location
    - How can a consumer know that the content is genuine?
    - How can a consumer know the credentials of the original publisher?

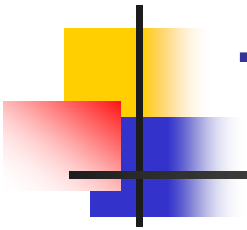


Content Issues:

- Generating **information navigation models** that have tight focus properties in terms of relevance of outcomes
- Generating **mutual trust models** that can be used to create information filters that generate trustworthy outcomes
- Adopting a **content economy** that funds quality of content

Information Navigation

- Currently in the early stages in combining formal systems with natural language interpreters and generators and flexible format interfaces
  - “Tell me where to look for an answer to my question”
- What I <u>really</u> want is
  - “Tell me the answer to my question”



Trust Models

- What is the trust model of the Internet?
- What do end-consumers want the trust model of the Internet to be?
- What do media providers and media intermediaries want the trust model of the Internet to be?

- Are these three views consistent?

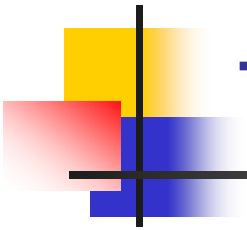
  Trust is difficult to impose and difficult to sustain. If you want a peer-to-peer content publication model then it has to be accompanied with a peer-to-peer trust model to sustain trust in content

The Content Economy

- What does a robust content economy look like?
  - Pay-per view?
  - Free to user – content provider funded?
  - Free to user - third party (advertiser) funded?
  - Bundled – access provider bundles cost of content provision?
  - How is Intellectual Property safeguarded in any model?

The Value of Content

- While the content market is increasing in value, it is important to distinguish value and volume in the context of the content market.
- High volume, replicated content has a low unit value to individual consumers
- Point-to-point individual services (such as mail), while low volume, represent the highest value segment of the content market
- Volume is not the same as Value in the Internet
- Value rules



The Larger Picture

- IP Packet Transmission is easy
  - well, most of the time
- IP Packet switching is easy
  - well, easy enough
- IP networks are easy
  - well, maybe not, but we believe we understand what the issues are

- Content is hard!
  - The evolving Internet content market is rapidly becoming the most critical issue in terms of value transfer, international trade, intellectual property, national wealth creation,...

Going forward

There’s a massive and different “out there” out there.

Somewhere - we just need to know where to look