The Current Status of Taipei GigaPoP

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Current Internet Status

- Internet has created unprecedented global interaction with tens of millions of hosts, hundreds of millions of users, exchanging petabytes of information contents
  - voice, data and video over a single Internet Protocol delivering all kinds of services via PC or Information Appliances (IA)
  - needs crucial culture and knowledge contents on the Internet to create the true Global Digital Library/ Museum
  - lacks of presentation and knowledge structure
    - Objective of Information search is finding the single most relevant document or object
  - Commercial predictions also include: E-Commerce and Internet Broadcasting

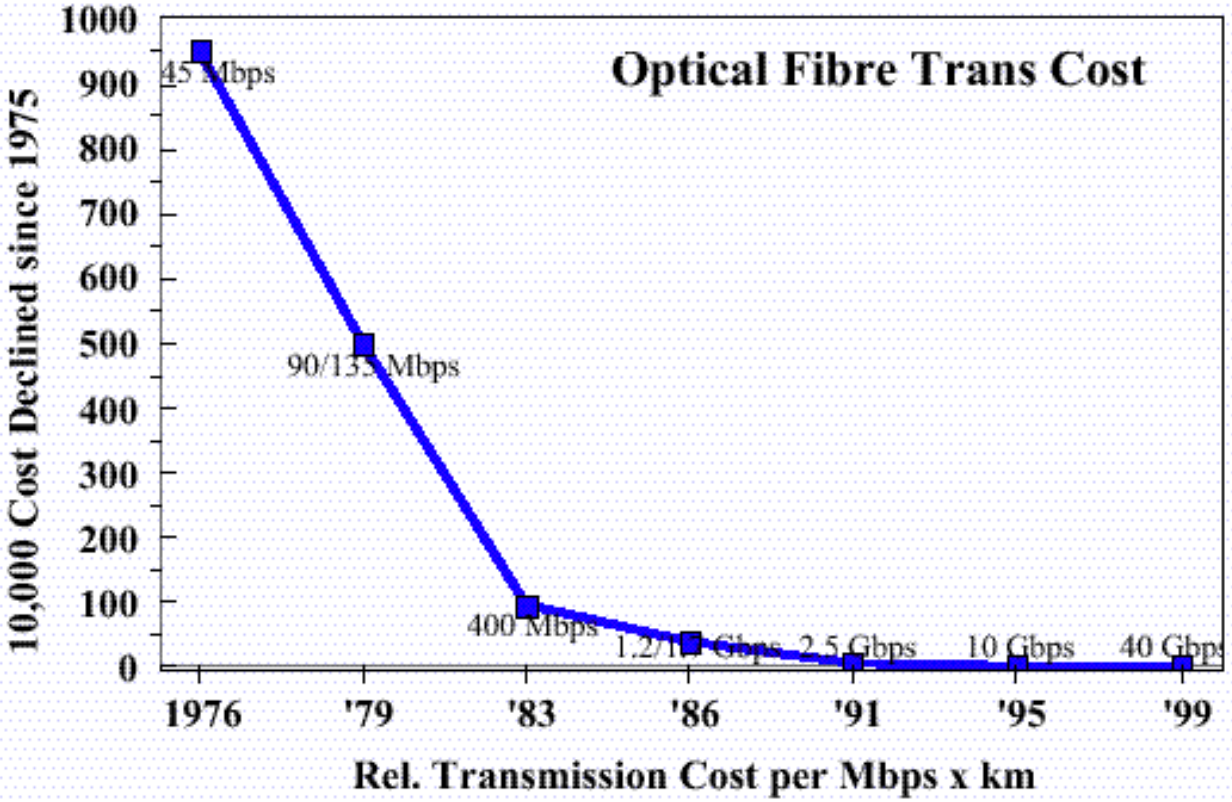
Internet Drives Knowledge Economy

- Knowledge Economy is Information Society where rules and practices for Industrial Economy must change in an interconnected world in which knowledge capital (abundance not scarcity) is more critical than other resources
- Interlocking Driving Forces
  - ◇ Globalisation
    - □ market, products and manufacturing all more global
  - ◇ Information / Knowledge Intensity
    - □ over 70% workers in developed economies are information / knowledge workers, even factory workers use heads more than hands (manufacturing is about quality not assembly).
  - ◇ Networking and Connectivities
    - □ Internet brings global village ever nearer
- Knowledge Economy is extremely human extensive, Current Potential Danger is Over-expectation

How about Network Infrastructure?

- Global trend of commercial Internet monopoly
  - International Internet is largely monopolied
  - Domestic Internet monopoly is a growing concern
- Separation between Research & Education (R&E) and Commercial Internet
  - Different momentum, may complement and leverage each other if strategically designed properly
- IP over ATM/SONET vs. IP over Fibre
- Technical challenges

Long Distance Fibre Cost



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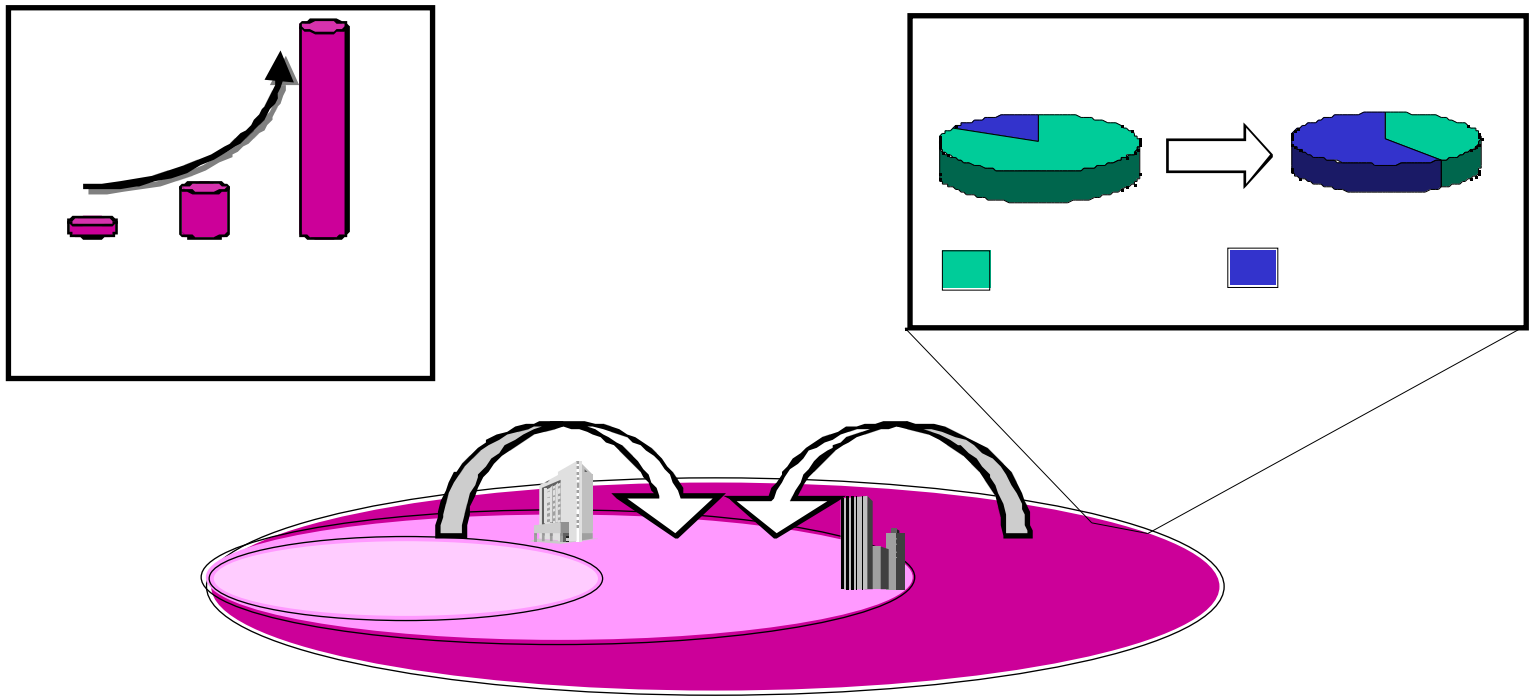
Metropolitan Network



Metropolitan fibre plant is demand pushed and pulled

Source : Nortel Networks

Public Network Strategy

- It must be an advanced initiative that can provide a platform for beta testing and technology transfer
- It should also accommodate R&E collaboration of advanced applications and industrial partners
- R&E network is a core ingredient and drive
- It may provide redundancy to commercial network with possible national routing centre in the future
- Swedish government is building public fibre infrastructure after it deregulate Internet and privatise Swedish Teli
- CAnet3 is another example

CAnet3 Experience

- Payback for dark fibre is from 6 months to 2 years
- Saving
  - □ eliminate the monthly charge for managed bandwidth
  - □ eliminate the servers at each individual institutions. maintenance, backups and software updates can be done more cost effectively at the central site
- Unlimited bandwidth makes schools to explore high end applications

◇ fixed one time costs: $7 to $15 per meter for all engineering, installation and construction services

◇ recurring cost such as right of ways, maintenance and conduit rental, e.g., underground: $1.05 per metre per year

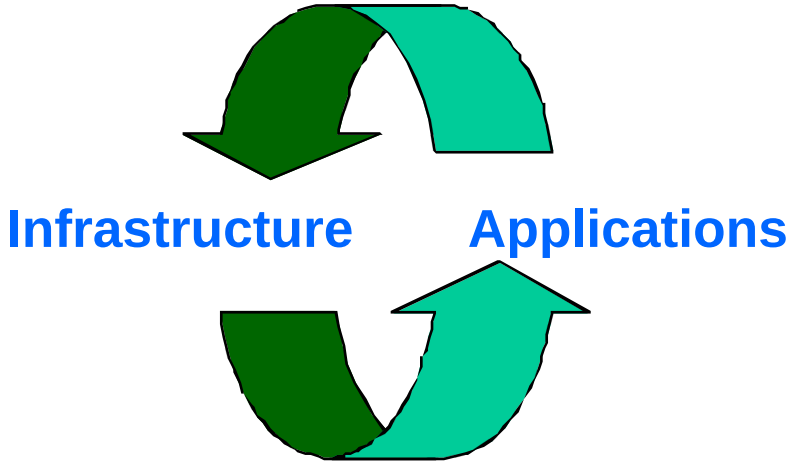
◇ maintenance contracts: 4 hours to get to the site and 2 hours to repair

Why IP over Fibre?

- Traditional model: IP over ATM / Frame Relay over SONET over Optical
- Optical Internetworking: IP over Optical Fibre
- Lower equipment cost
- Lower operational cost
- Simplified architecture
- Scalable capacity

Evolution of Advanced Infrastructure

- Demand (applications) creates its own supply (infrastructure)
- Supply (advanced infrastructure) creates its own demand (advanced applications)



Technical Challenges

Capacity Provisioning

- During the peak periods, network operation should have at least 30% to 40% spare bandwidth
- 50% or more spare bandwidth can handle bursts of traffic and reduce packet loss
- Important issue: it takes 45 to 90 days to get T3 lines installed
- R&E network provider should articulate a coherent strategy to meet tomorrow's demands (DWDM, IP over fibre)

Network Capability

- Reliability
- Robustness
- Security
- QoS
- Network management

Reliability

- Redundant paths
- Diversity
  - guaranteed traffic keeps on travelling
  - loops are routed over different fibre connections
- Never say never
  - Worldcom Inc. lost 500 T3s in a massive fibre cut in July 1996
  - Taiwan island-wide power outage on 29 July 1999
  - don’t put all eggs in one basket

Network is in Trouble

- Fibre cut
- Route flapping
  - There's more damage done on the Internet because of errors in BGP programming than because of fibre cut
- Packet loss means double trouble
  - Traffic is delayed
  - Congestion continues to build, since dropped packets are automatically retransmitted

Quality of Service

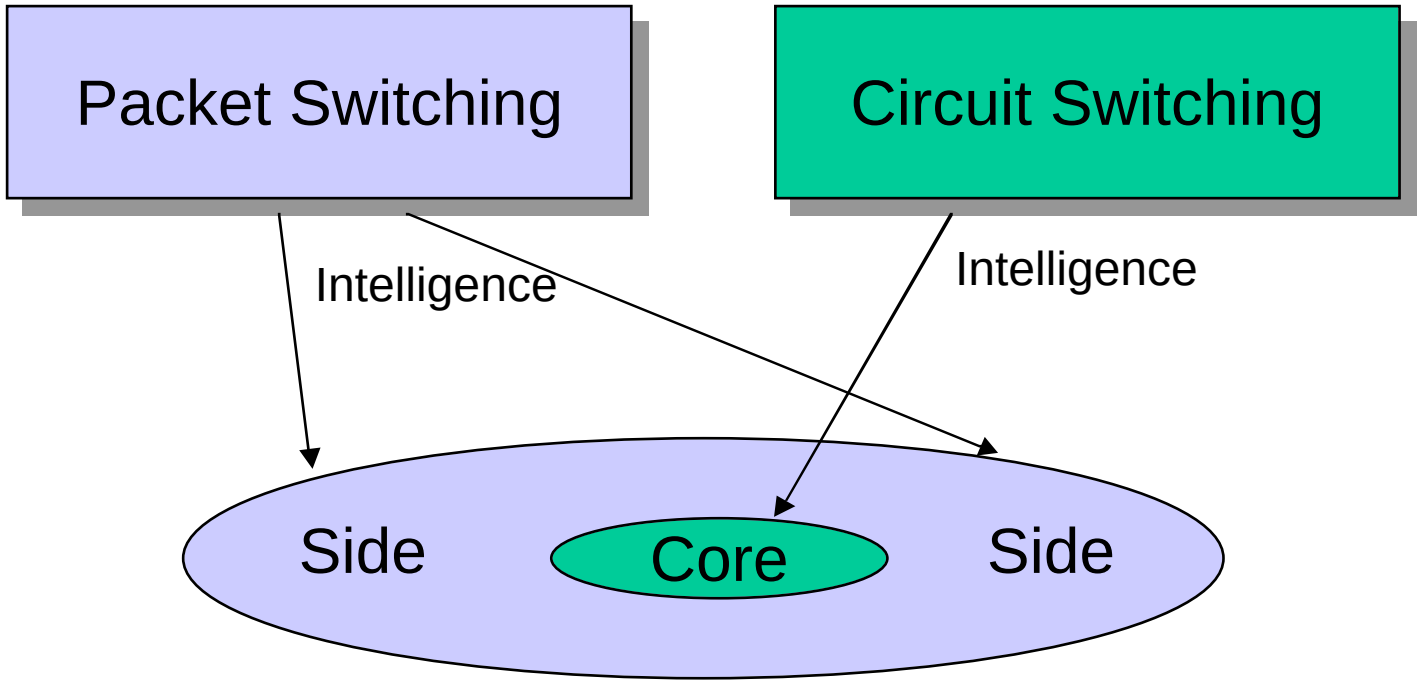
- delay
- jitter
- traffic controls
- end-to-end
- bandwidth reservation

Dilemma of QoS

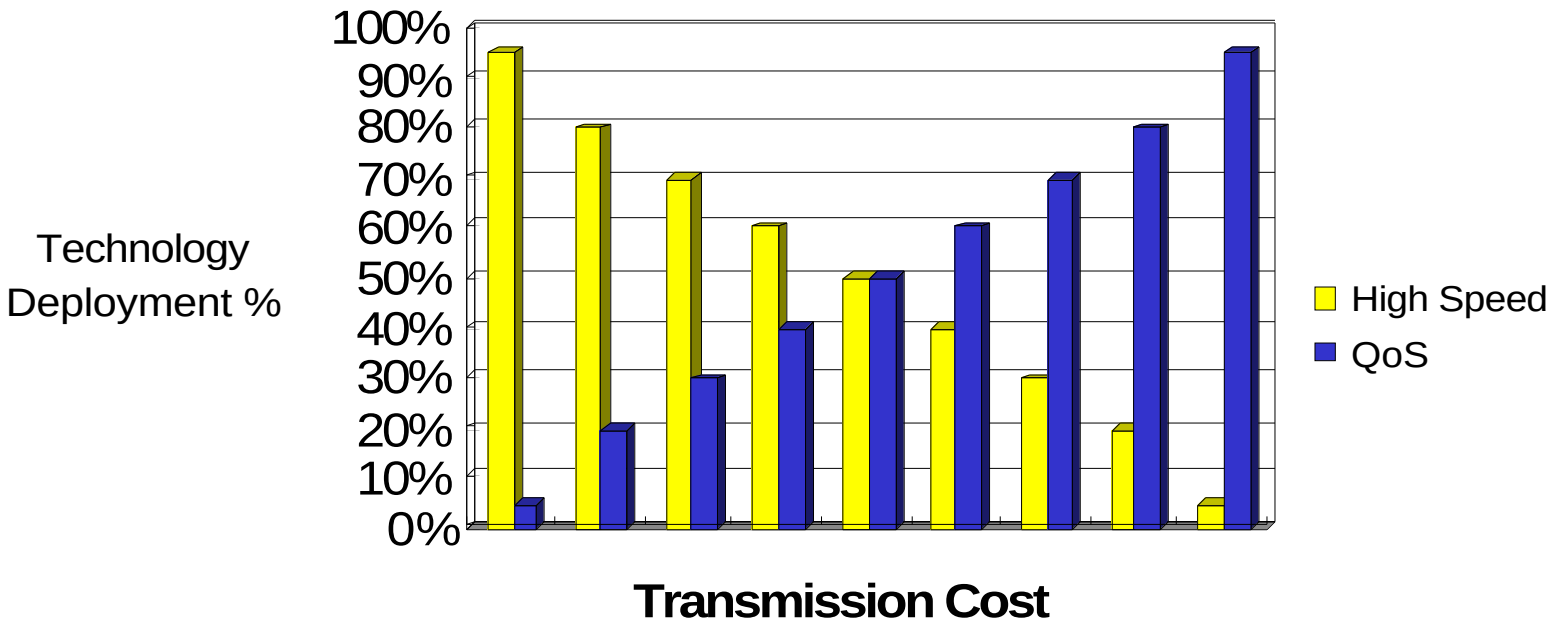
- High speed vs. QoS
- Jitter vs. Delay
- Intelligence at side vs. Intelligence at core
  - behaving circuit- switching

Model of Intelligence

- Circuit-Switching vs. Packet-Switching



QoS Deployment Strategy



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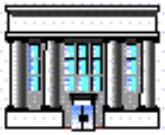
R&E Network Operational Trend

1987  Application-based QoS

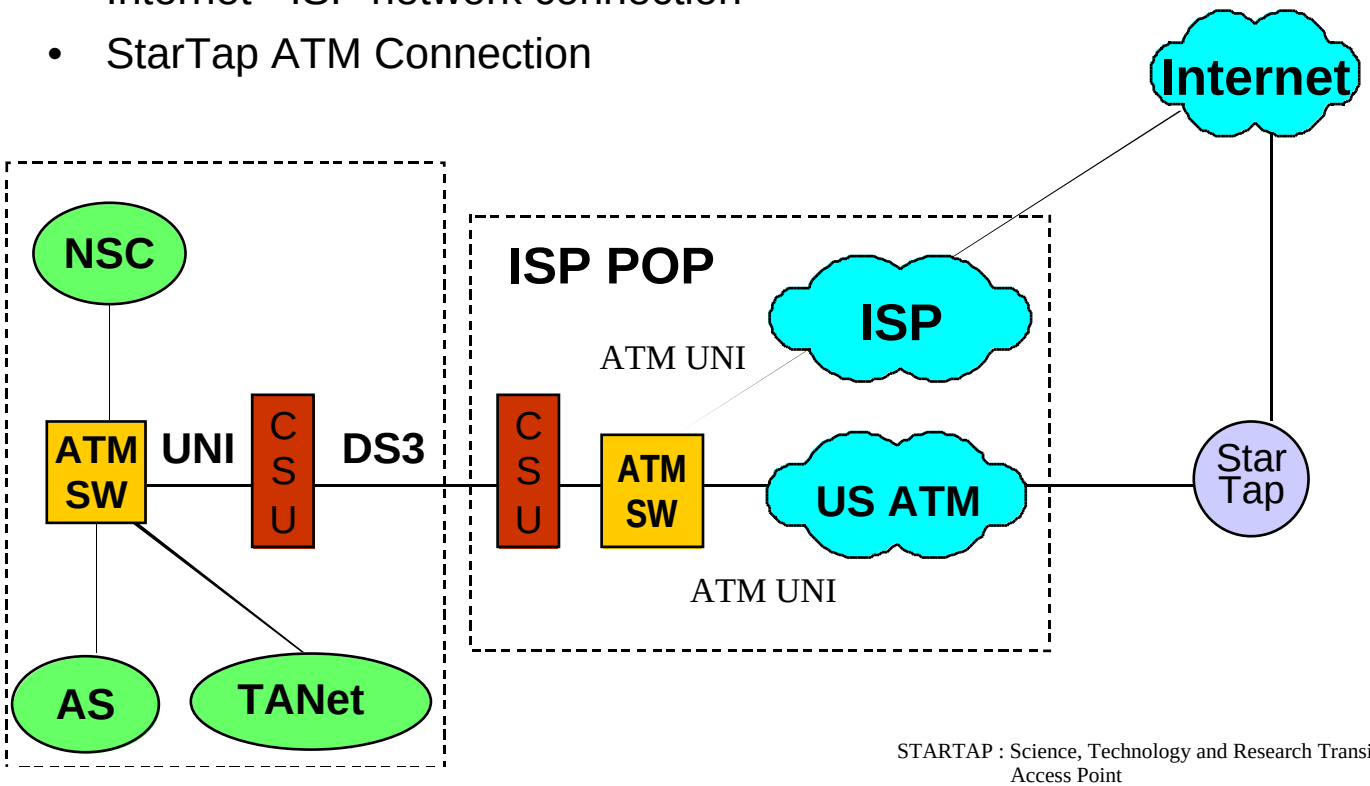
1988 - 1996  Capacity Expansion

1997  Capacity Expansion  Organization-based QoS

2000  Diff-Serv QoS

Taiwan T3 International R&E Network

- Internet - ISP network connection
- StarTap ATM Connection



STARTAP : Science, Technology and Research Transit Access Point
AS : Academia Sinica
NSC : National Sciense Council
TANet : Taiwan Academic Network

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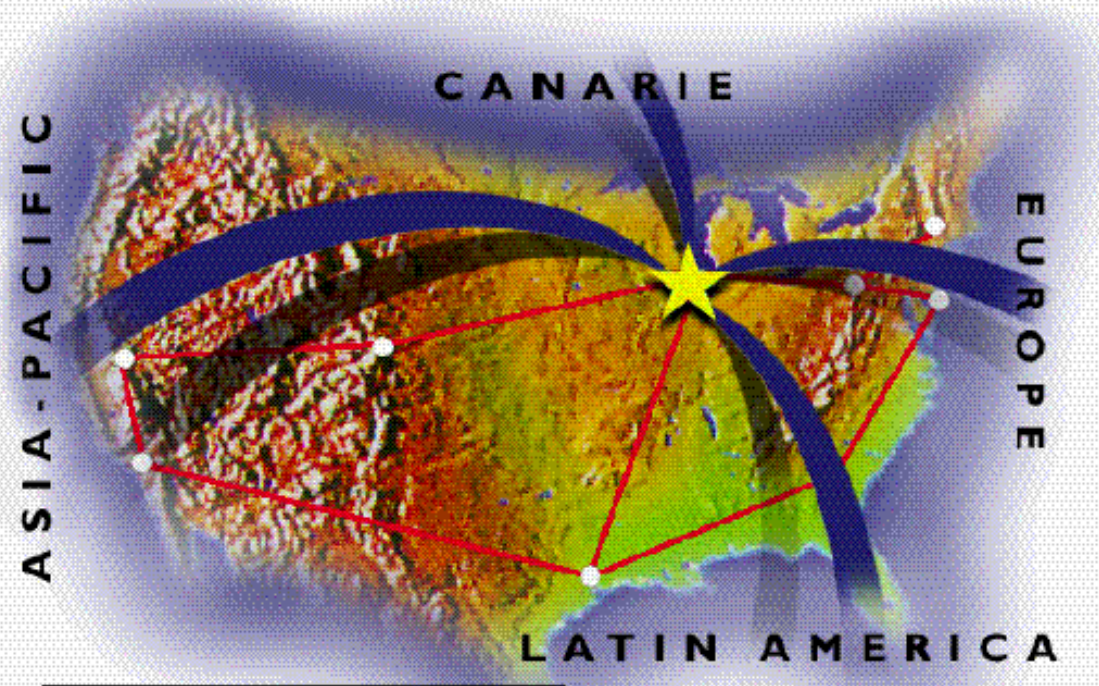
STAR*TAP Topology



High-performance networks from across the United States connect with international networks at the STAR TAP access point in Chicago, Illinois

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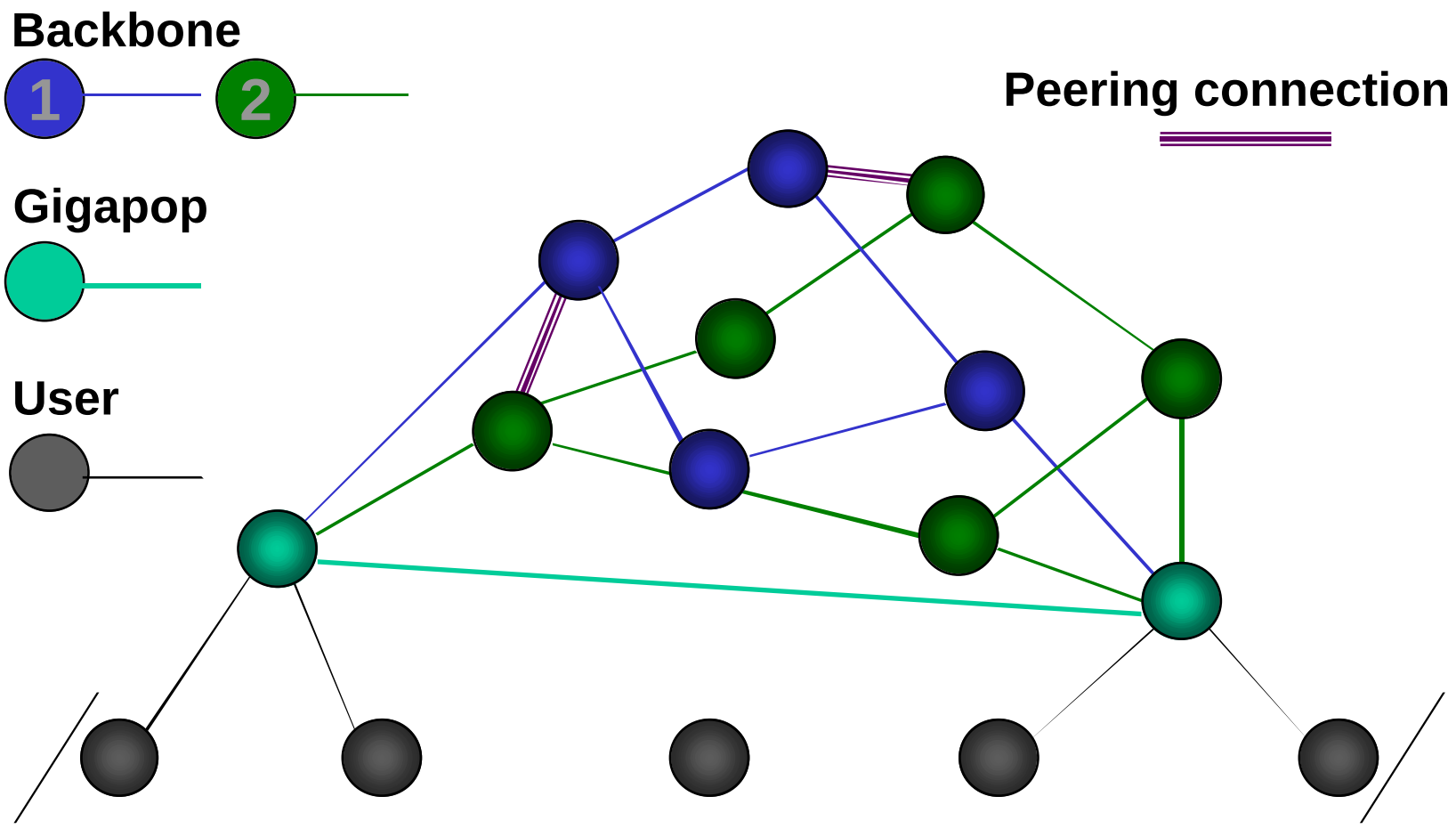
Internet eXcange

- Internet = Networks + eXchange Points
- Connectivity = Valuable Resource
  - The administrative complexity of maintaining route aggregation
  - Technology does not fully support sophisticated meshed architecture
  - IP renumbering cost
- From CIX, FIX, NAP to GigaPoP

What is a GigaPoP

- Point of aggregation
- Provides local traffic exchange
- Variety of speed
- Point of policy implementation
  - telecommunication regulation
  - AUPs Portal
- Point of backbone uplink
- Buying power and shared use between collaborating partners

Topology Needs



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Geography Issue

- The location of GigaPoPs would be chosen to keep the "last- mile" cost as low as possible for all members
- Metropolitan area with a high population density
- 90% of Internet traffic in Taiwan is exchanged in Taipei, thus, Taipei GigaPoP

GigaPoP Services

- Resolution to current metropolitan network problems
- Platform for adventurous service models deployment
- good old IPv4
- Content co-location
- Cache Service
- High capacity & reliability
- Best effort QoS vs Bandwidth
- Multicast
  - one sources to many receivers (lectures)
  - few sources to few receivers (meeting)

Enhanced Network Services

- IPv6
- Portal Computing
- Network Management
  - monitoring and measurement
- Policing
  - filtering
  - traffic control
  - queue management

Taipei GigaPoP Plan

vBNS

CAnet

ISP

HARNet

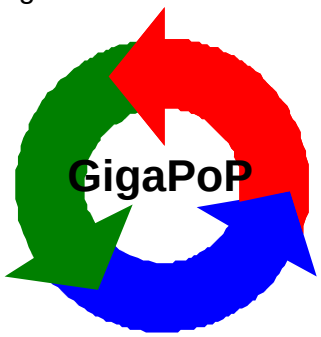
AUP Full

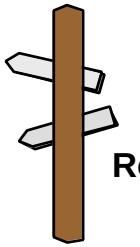
Peering

Peering

Transit

Peering

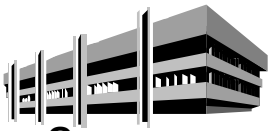




AUP
Routing Policy

Last Mile

Lab



Campus

Institute

university

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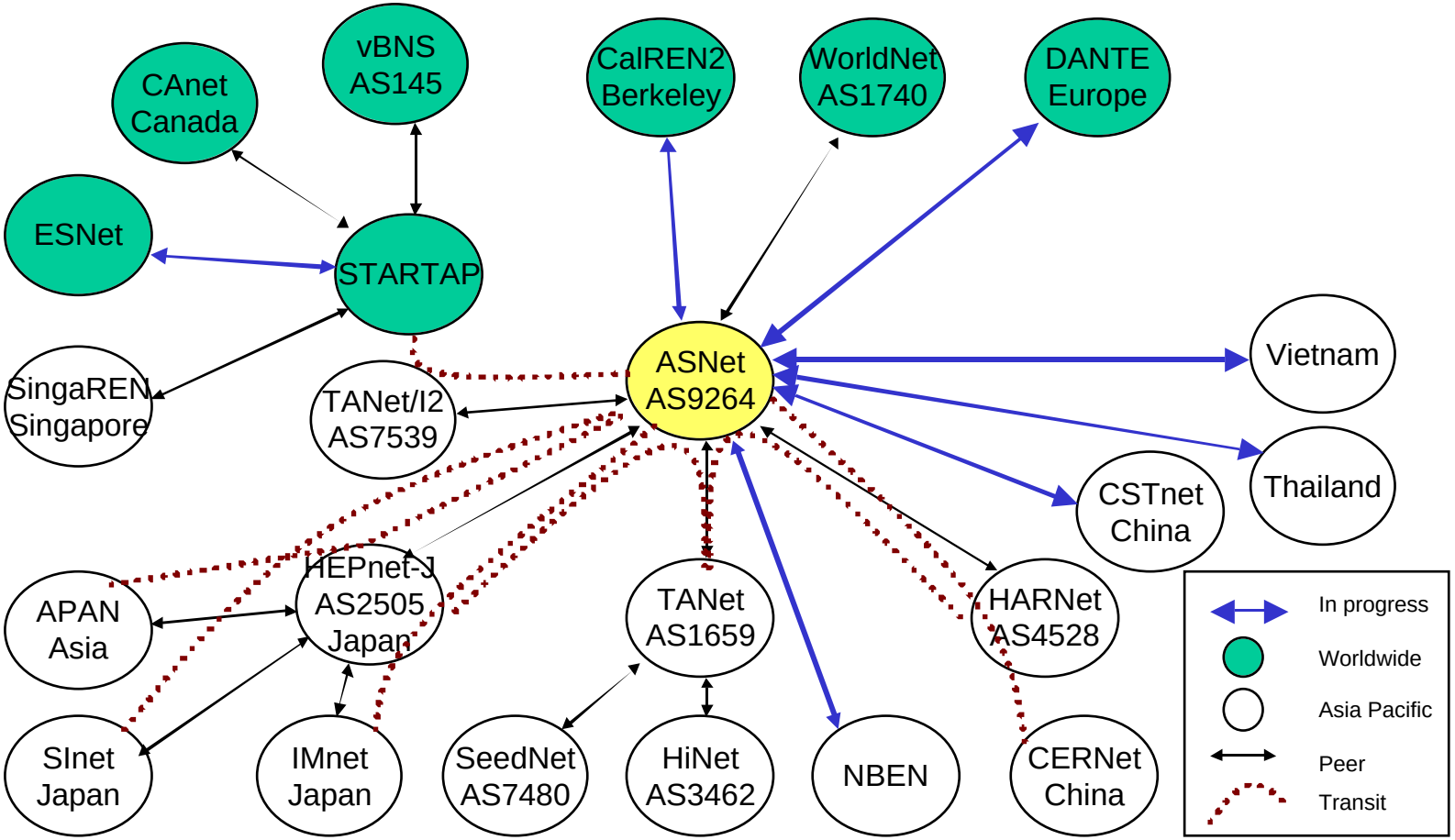
Routing Policy

- R&E Network AUPs
- Commodity IP SLA
- Peering Agreement
- Transit Agreement
- Traffic Exchange Agreement
- GigaPoP Access Agreement

Academia Sinica BGP Peers



29 July 1999

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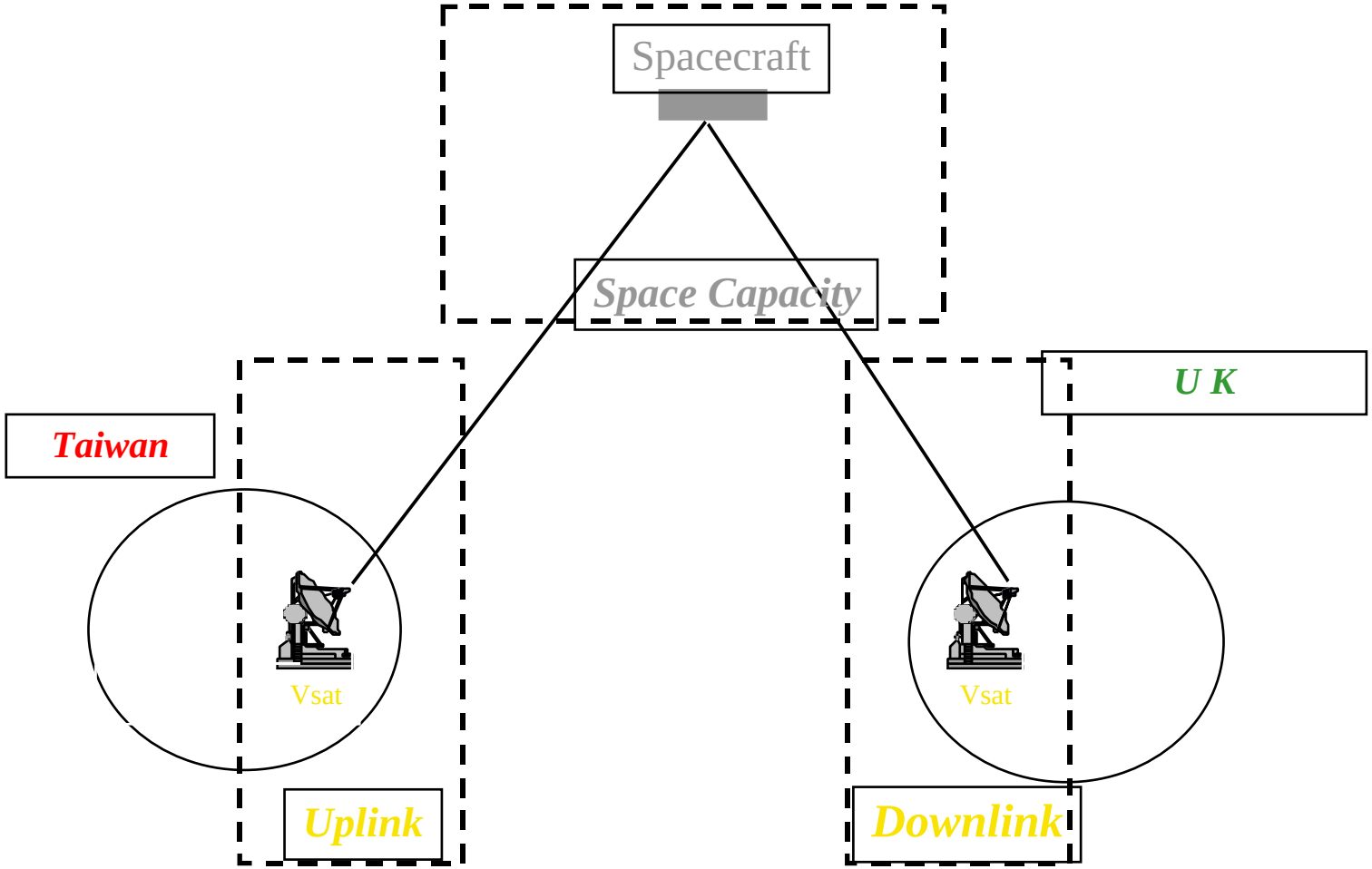
Academia Sinica Satellite Links



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Milestone

- Sinica campus GigaPoP implementation (Q2 1998)
- Taipei GigaPoP initiative meeting (Q2 1998)
- Taipei City Government meeting (Q3,Q4 1998)
- Fibre burial planning (Q1 1999)
- Taipei City Government meeting (Q2 1999)
- Taipei GigaPoP-NBEN joint program (Q3 1999)
- Taipei GigaPoP meeting (Q3 1999)

Status

- Academia Sinica works:
  - physically walking the possible route where the fibre will be deployed
  - identify conduit, road, river and rail crossing
  - design, planning and cost estimation
- Modify rules of facilitate the burial of cable along drainage
- RFPs for fiber infrastructure and network systems
- Budgetary relocation due to the quake

Implementation Progress

- Fibre infrastructure RFP - Q4 1999
- Network integration RFP - Q4 1999
- Negotiations with providers completed - Q4 1999
- Connectivity described by network RFP - Q1 2000
- We will use G655 fibre running OC192 (10 Gbps) with potential 200x MWDM in the future

Future Works

- Phase 2 would include partners of Taiwan National Digital Archive such as National Palace Museum, National History Museum, National Library, etc.
- Hospitals, municipal governments, libraries, community colleges are potential partners
- ROW management
- Route management (route registry)
- Encourage UDP services
- QoS assurance (min guaranteed bandwidth and max allowable bandwidth)

The Bandwidth Iceberg

Conclusion

- Say goodbye to circuit-switching, IP will dominate
- Core Technology: QoS and Multicast
- More bandwidth - WDM technology
- R& E QoS solutions
  - Path Guaranteed
    - Dedicated networks
    - Mesh topology
  - Broadband Technology
- Developing network communities for culture and knowledge content should work hand-in-hand with the building of network infrastructure