Y-Comm – Exploring a New Architecture for Heterogeneous Networking

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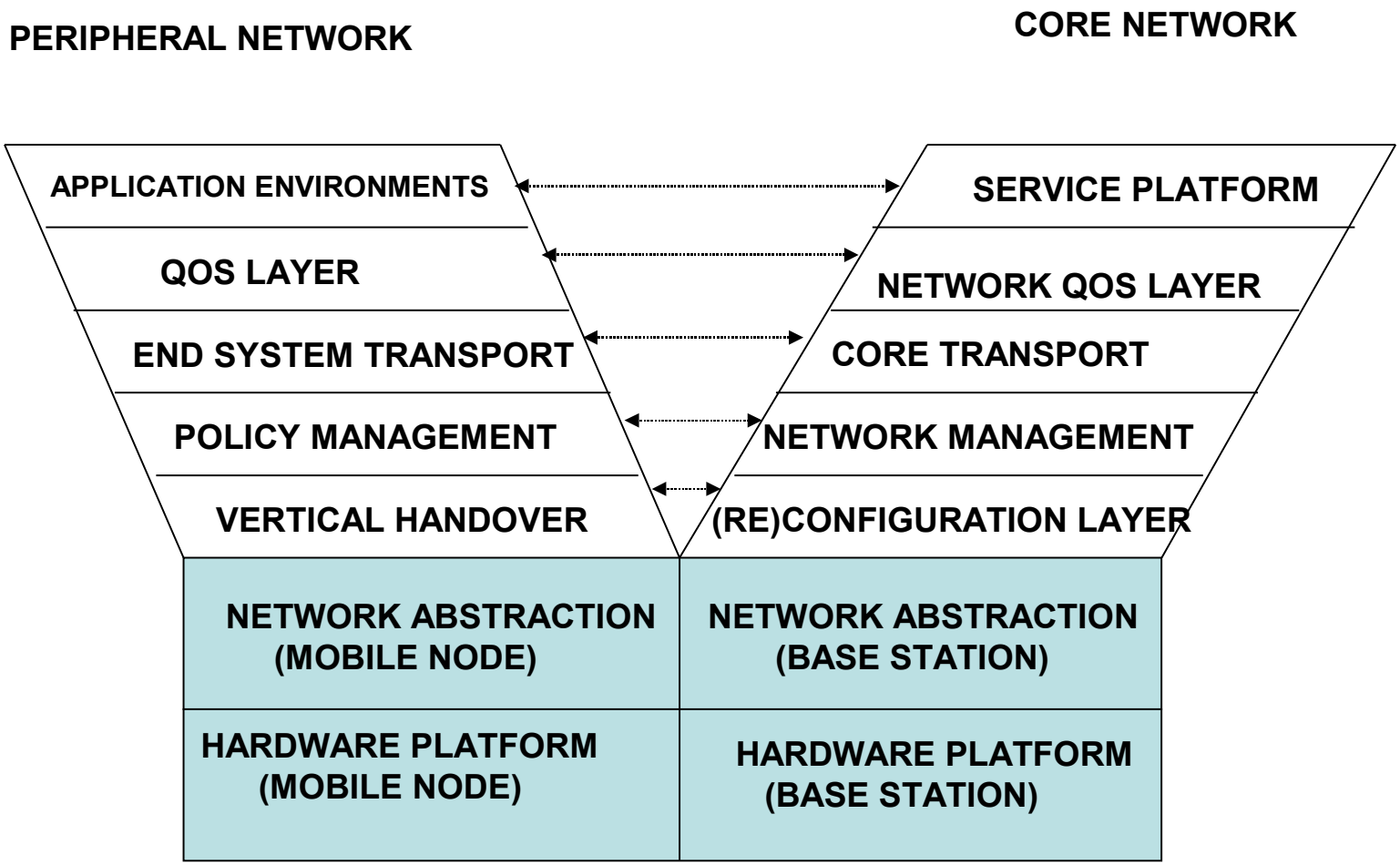
A Complete System for Heterogeneous Networking

- In order to build a complete system that
  - Does seamless vertical handover
  - Is extensible – seamlessly adds new technology
  - Is easy to develop new applications
- Requires a lot of work
  - Can't do this from scratch
  - Need to also look at what other people are doing
    - Ambient networks, etc
    - IEEE 802.21, etc

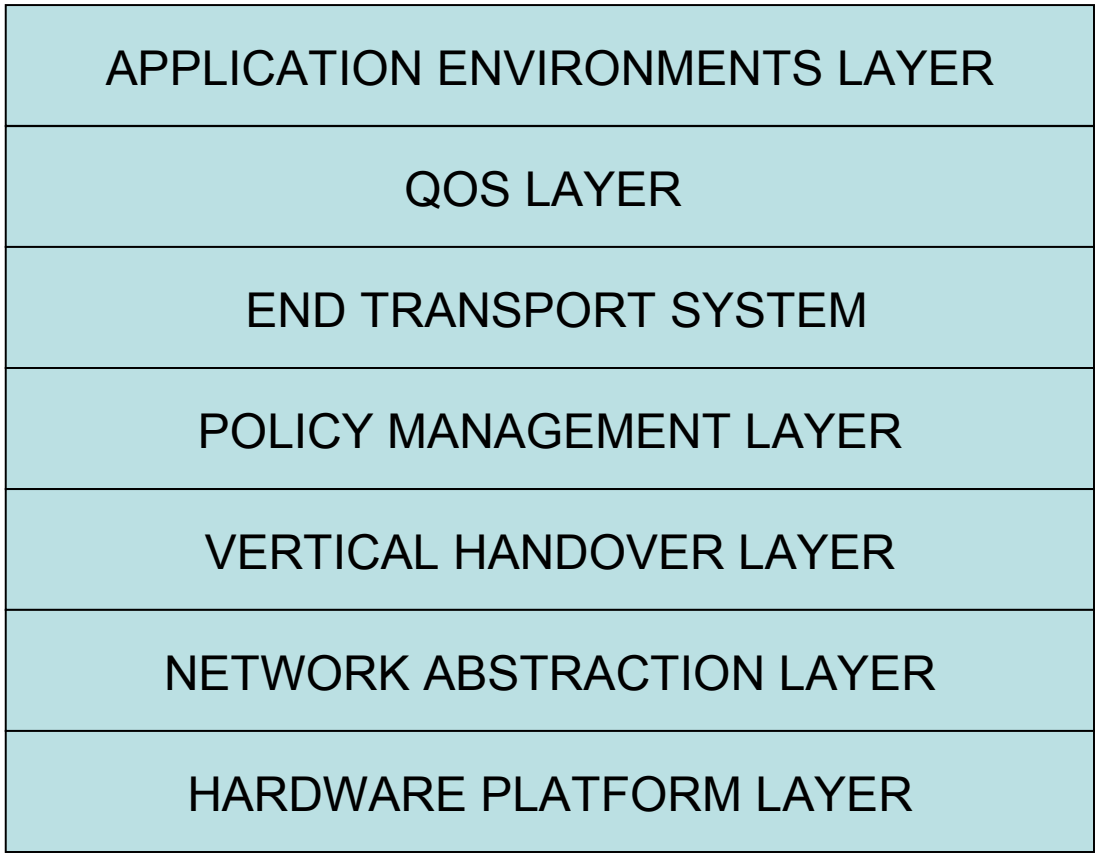
We Need Two Not One!

- A framework for the Peripheral network
  - Represented by software running on the mobile node, supports:
    - Applications, QoS, Vertical Handover, support for several interfaces
- A framework for the Core network
  - Represented by software running in the network, supports
    - Programmable infrastructure, network management, QoS, Service Platform

The Y-Comm Framework



The Peripheral Framework



Do we really need the Core Framework?

- Yes
  - To support the Peripheral networks you need to change
    - For client-based handover we need to have access to network resources
      - Need a more open architecture
  - But we also need an open architecture for other reasons

Open Management Needed

- More diversified networks needed
  - Present mobile networks are built on a national or international level: -
    - just like the old state-owned telecom companies
      - such as BT
  - Difficult to really produce more tailored networks such as regional networks or city-wide networks
    - Value added services
      - Customers will pay for these value-added services
        - » E.g. weather or traffic news about London

Open Management Needed

- So the question is who is really making money from mobile systems at the moment??
- The answer:
  - Very few people
    - Vodafone, T-Mobile
      - Spent loads of money on spectrum, they need to grow bigger to recoup the money spent
    - These companies are highly vertical institutions
      - Same company does hardware, manage the network and also run or tailor most applications

Open Management Needed

- More niche players
- Let different players provide different components of the network but everyone needs to agree on a new framework and related standards
- Compare this to what happened with the PC industry

Open Management Needed

- 1960's – 1980's
  - Main Frame or Minicomputer
  - Dominated by IBM and DEC
- 1978
  - Altair the first micro-processor
    - Bill Gates and Paul Allen wrote Basic compiler
- 1982
  - The IBM PC released and that changed the world

Why did the IBM PC changed the world

- It allowed third parties to get involved and therefore allowing a mature industry to develop with many niche/specialist players
  - Visicalc, Eudora, etc
- Because of DOS
  - A broken but open operating system
    - But it was the standard
      - Allowed new people to write applications
      - You didn't have to be IBM or DEC

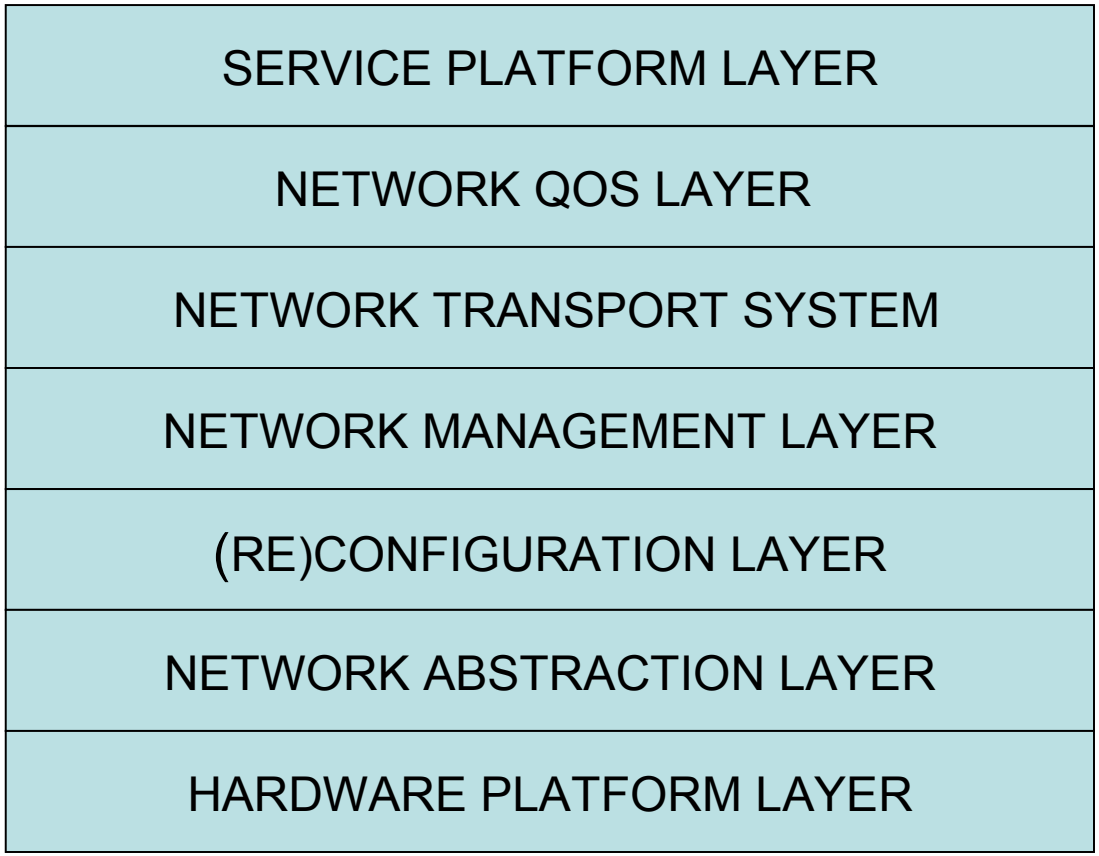
How far are we from an open architecture?

- Far: but there have been developments to try and get us there
  - Programmable networks
    - xBind
- The real problem is that a lot of this never made it to the wireless network infrastructure

Also need a complete Framework

- If you really want to do this properly
  - you need a new framework
- Key issues
  - Network management and control
  - Things you want to support from the Peripheral Framework
    - Vertical Handover
      - Client-based Handover
    - QoS, Support for Applications and Services

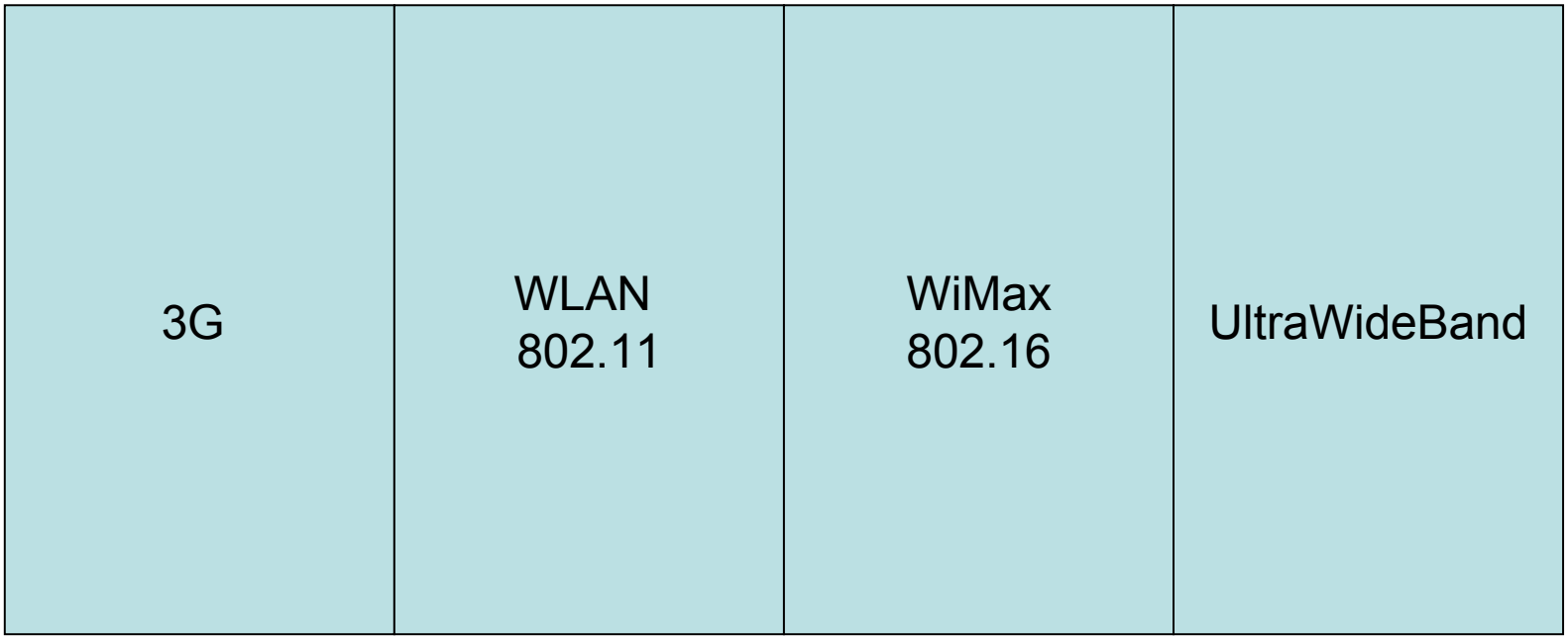
The Core Framework



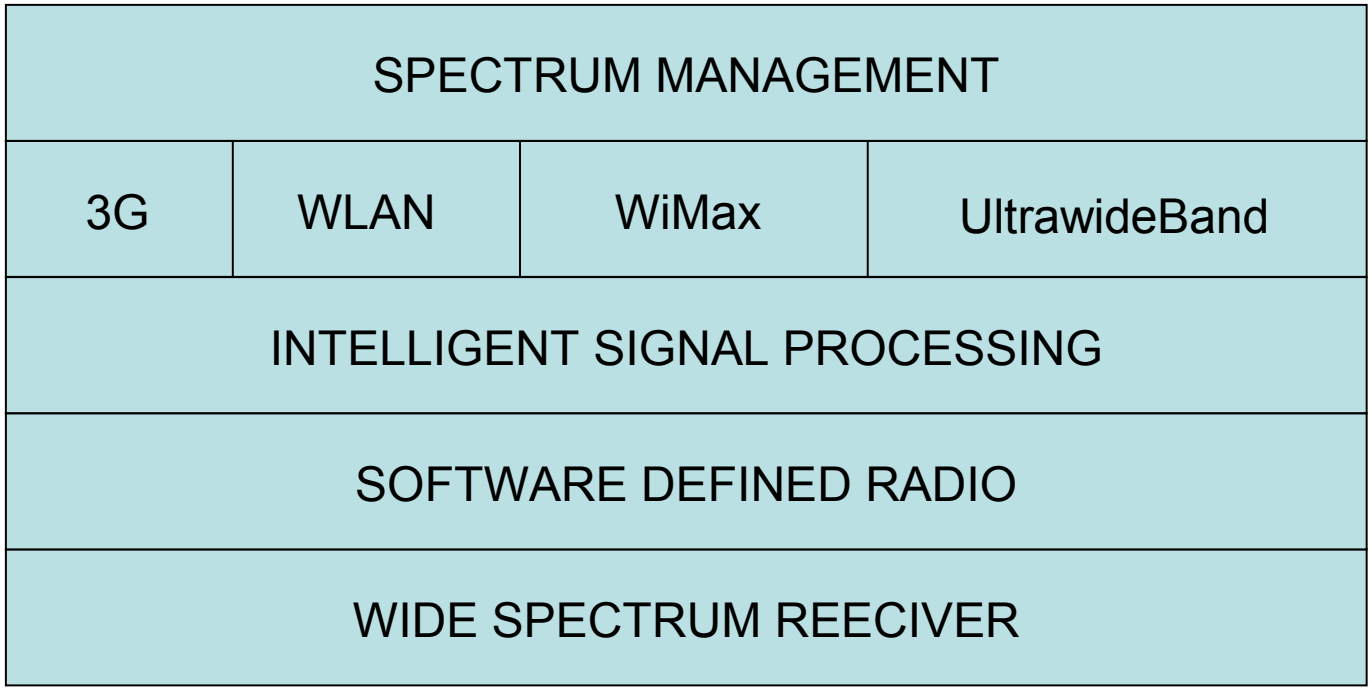
Hardware Platform Layer

- Similar to Peripheral network
  - Supports a number of wireless networks
  - Includes Base-station technologies
  - Different technological settings
    - Technologies in the same box
    - Technologies in different boxes

Hardware Platform Layer Represented as Vertical Components – different base stations



Cognitive Radio will change this as it will all be done in the same box



Network Abstraction Layer

- Again similar to Peripheral Network
  - Abstraction that abstracts a number of different wireless technologies
  - Also includes base-station controller functions
    - Extension of 802.21
  - Exportable interface so that the base-station can be remotely controlled
  - Monitoring and reporting functions

(Re)configurable Layer

- Controls core infrastructure including routers and switches
  - Programmable hardware
    - Routelets and Switchlets
    - Already used internally in network equipment but not exported to external systems especially end-devices
    - It is needed to support client-based handover

Programmable Networks (PNs) A brief history

- The idea started with the Xunet program
  - Program that built a research communications network throughout the US
    - Sponsored by AT&T
    - Laboratory without walls
  - Xunet 1 used DataKit switches
  - Xunet 2 used ATM
    - Pushed understanding of ATM networks
    - Looked at management and control issues

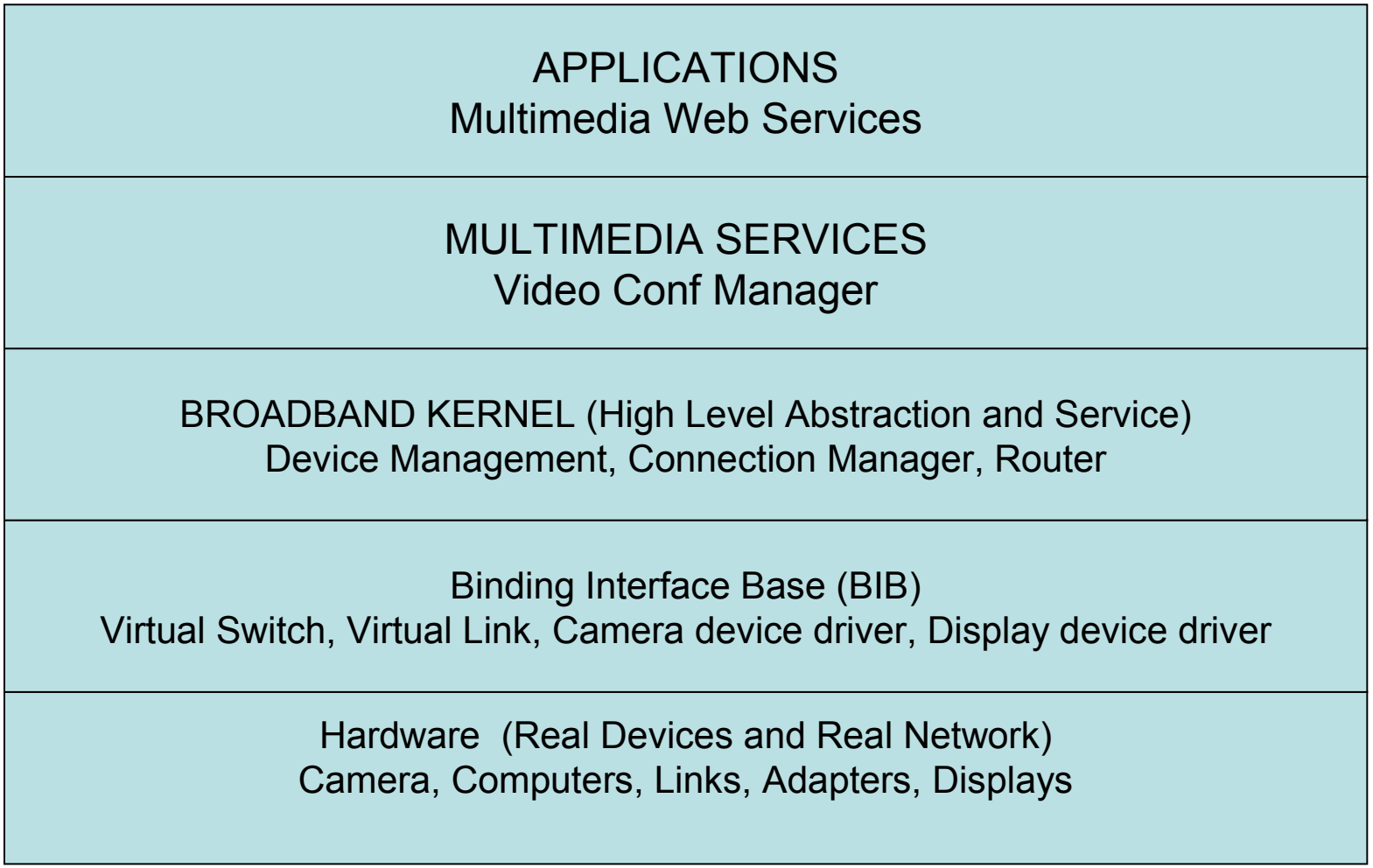
Programmable Networks
A brief history

- Columbia University joins Xunet 2
  - Led by Aurel Lazar
    - Interested in network management issues, etc
- Aurel proposes XBind
  - Hardware represented by software abstractions
  - Use that abstraction to build real applications
  - Similar to an operating system
    - Xbind was called a broadband kernel
    - Instead of devices, it was controlling network hardware

Xbind

- So the big idea of Xbind is that we could use it as a kernel and virtualize network infrastructure through the broadband Kernel
- Layers of XBind
  - Applications (WWW Server)
  - Services (e.g. Multimedia services – video conf)
  - Broadband Kernel – Management Plane
  - Binding Interface – Abstraction of real Hardware
  - Real Hardware

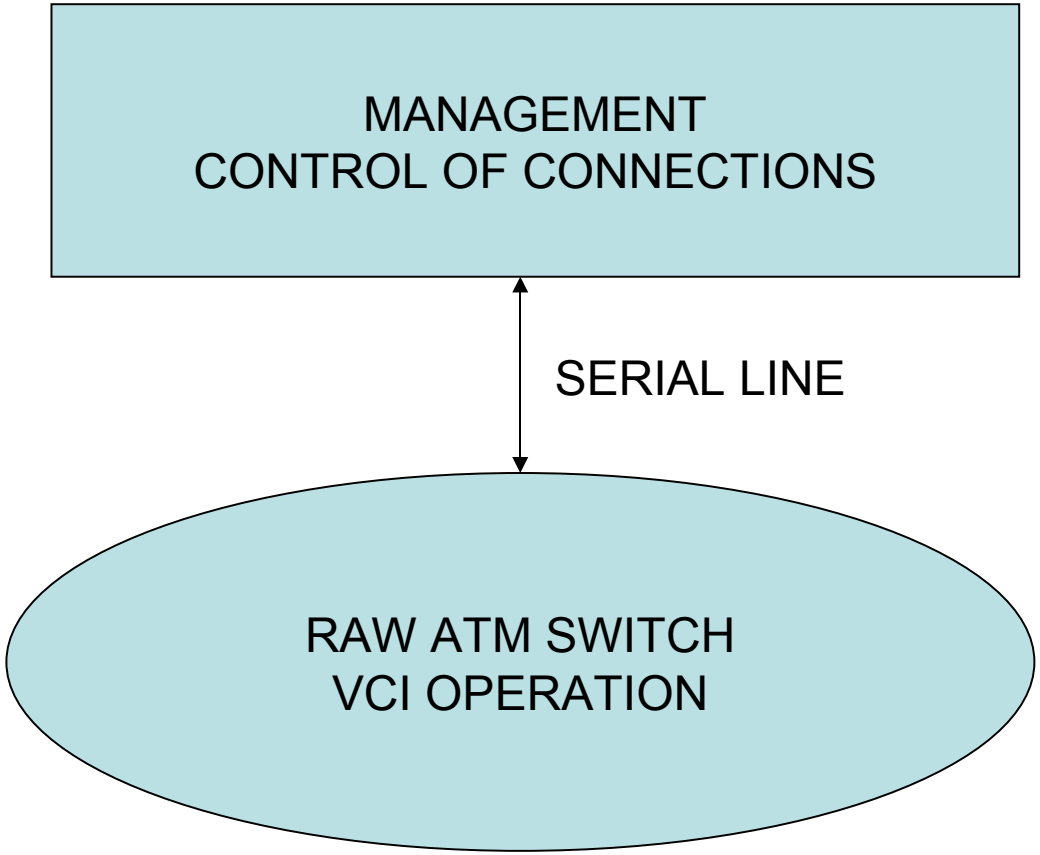
XBind – The Layers



Extensions of the X-Bind Key Ideas

- Since we can control the hardware virtually using software, the hardware and the software need not be in the same box
  - Make the hardware box only understand the interface
  - Talk to the box over a serial link using a computer
  - Control software runs on the computer

X-BIND: The extensions



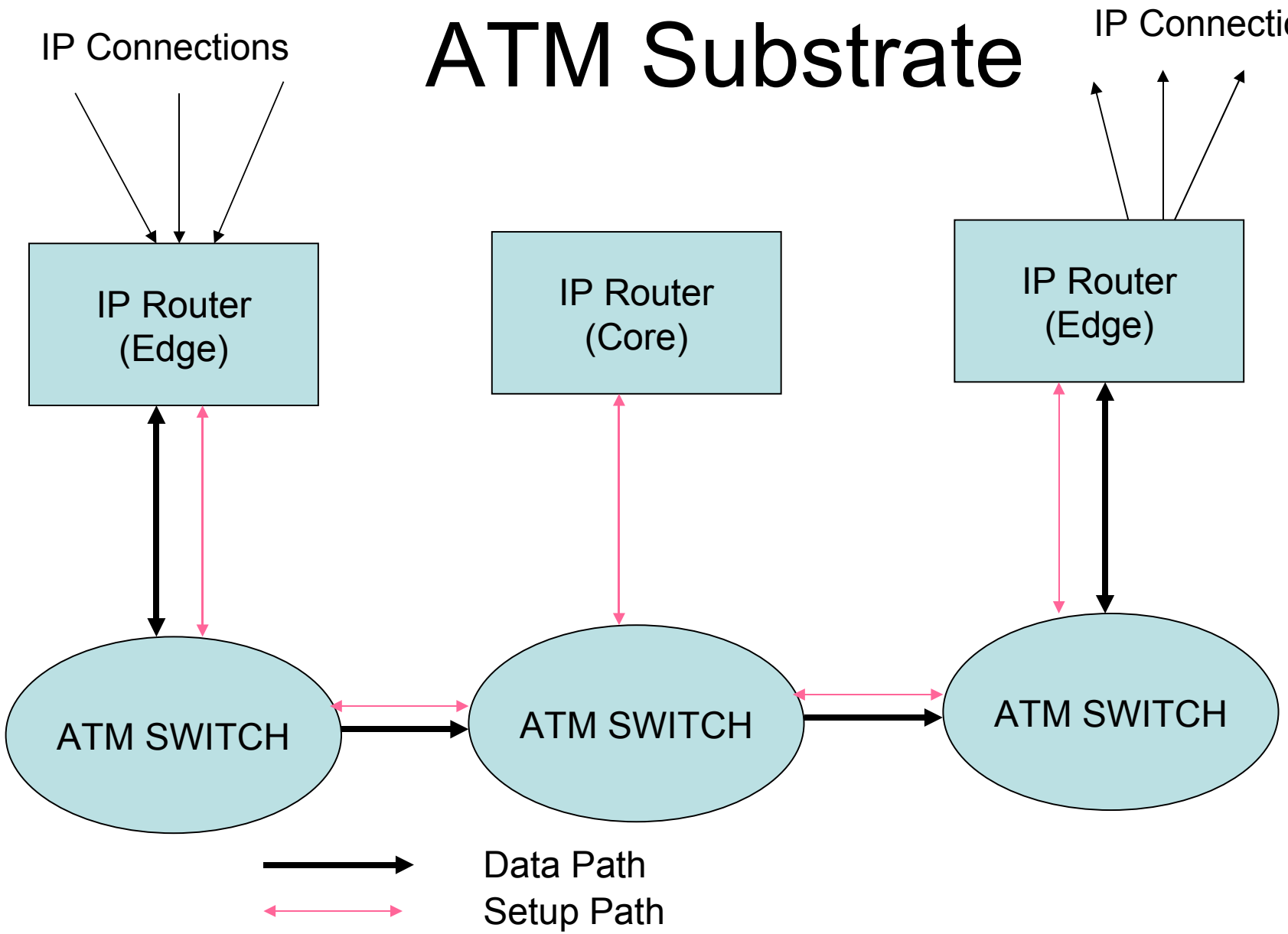
OpenArch and OpenSig

- You need a management protocol to manage the switch
- You also need a signalling protocol
  - You need to agree on the format of the commands that go across your serial line
- Two forums were established to do this
  - OpenArch – management plane
  - OpenSig – for signalling

Clever stuff by Ipsilon

- This method offers us a way of using ATM transparently in an IP Network
- Let's suppose the control boxes were IP routers, so they understand IP.
- Use IP to do the routing but the actual data transfer was done using ATM
- Proposed by Ipsilon
  - Founded by Tom Lyon and Peter Newman
  - Proposed GSMP for ATM Switch
  - Made a lot of money

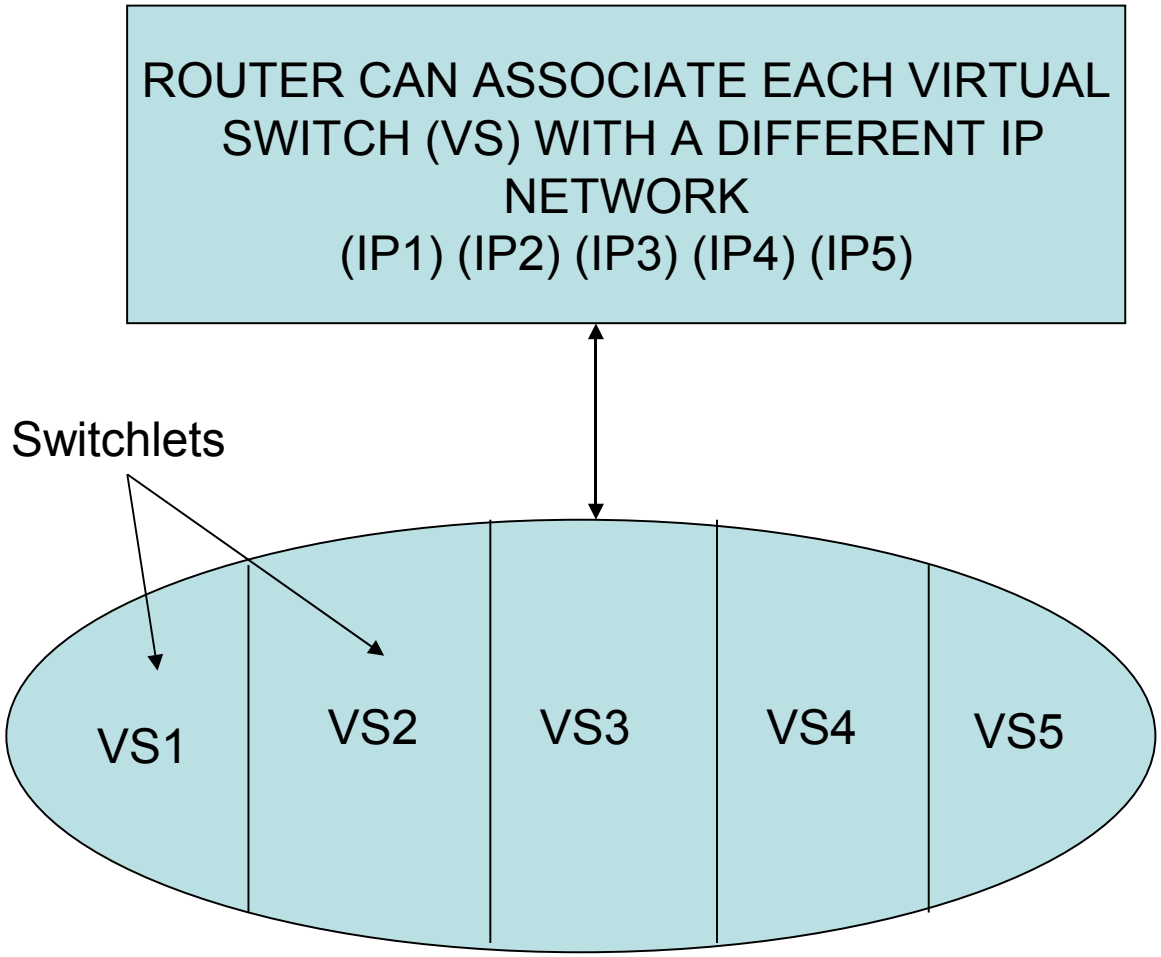
ATM Substrate



Other Key Idea from Xbind

- Why not virtualize not just the interface but virtualize the box as well.
- Concept similar to virtual machines
  - Vmware and Xen
- So a physical switch can in effect support a number of virtual switches that do not know that they are running on the same hardware

Switch Virtualization



Switch Virtualization

- First suggested by the people at Cambridge
  - Ian Leslie, Kobus Van Der Merwe, Sean Rooney
  - Developed a switch interface called Ariel
  - Suggested extensions to GSMP
    - CPlane – a company to exploit this idea

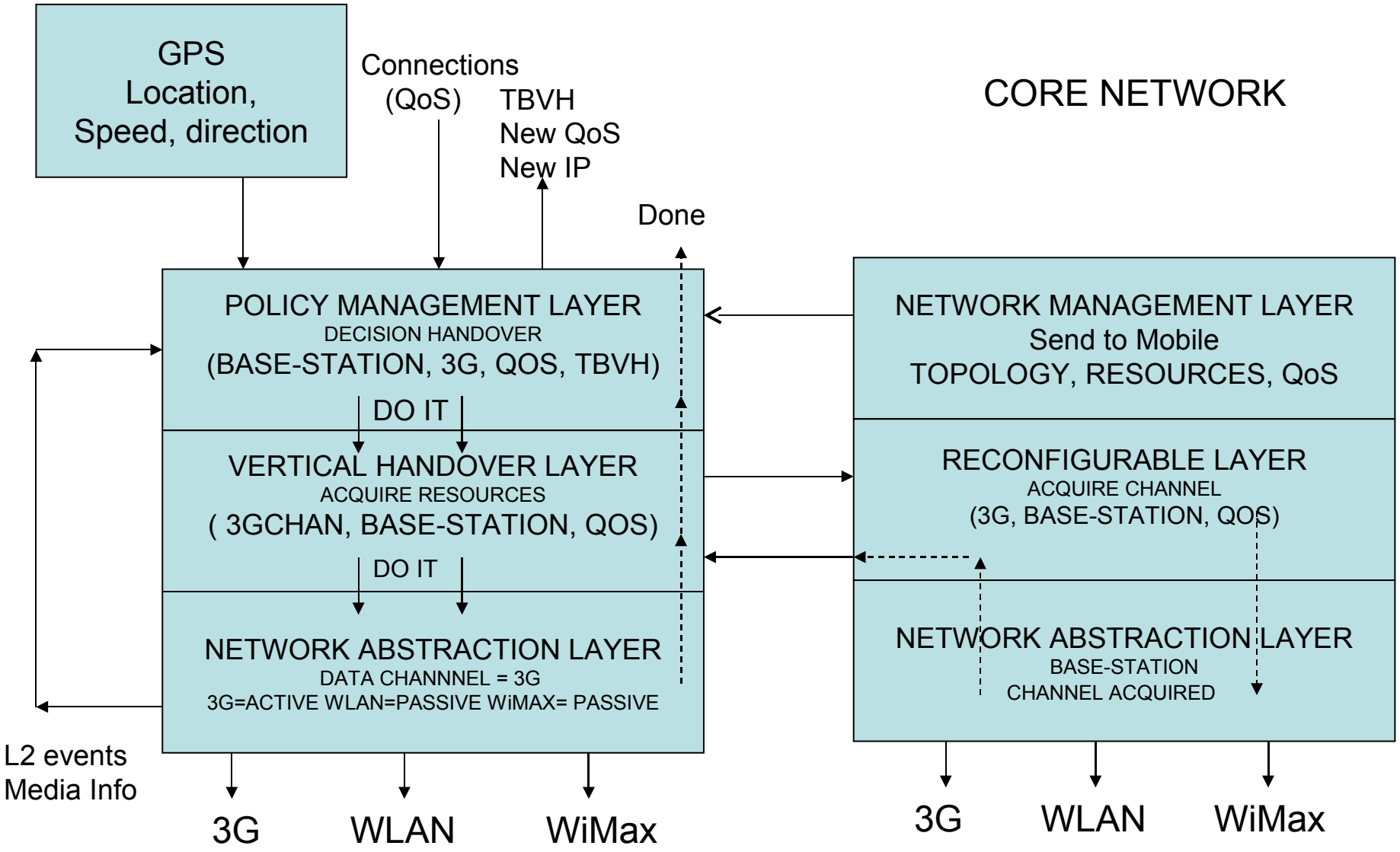
What happened to the Programmable Network work

- Got overtaken by active network research
  - More funding from the US military for ANs
  - Public research money dried up for PNs
- Was too closely attached to ATM
  - MPLS, same idea as ATM but based on IP , wasn't keen on open architectures
- Related companies died in the dotcom bust

Why do we need it now?

- Because we need resources to do vertical handover, especially for client-based handover
- We have to get those resources from the network
  - Channels on base-stations, QoS, etc
- We have never had open interfaces for mobile systems
  - Base-stations, BSC, MSO, etc

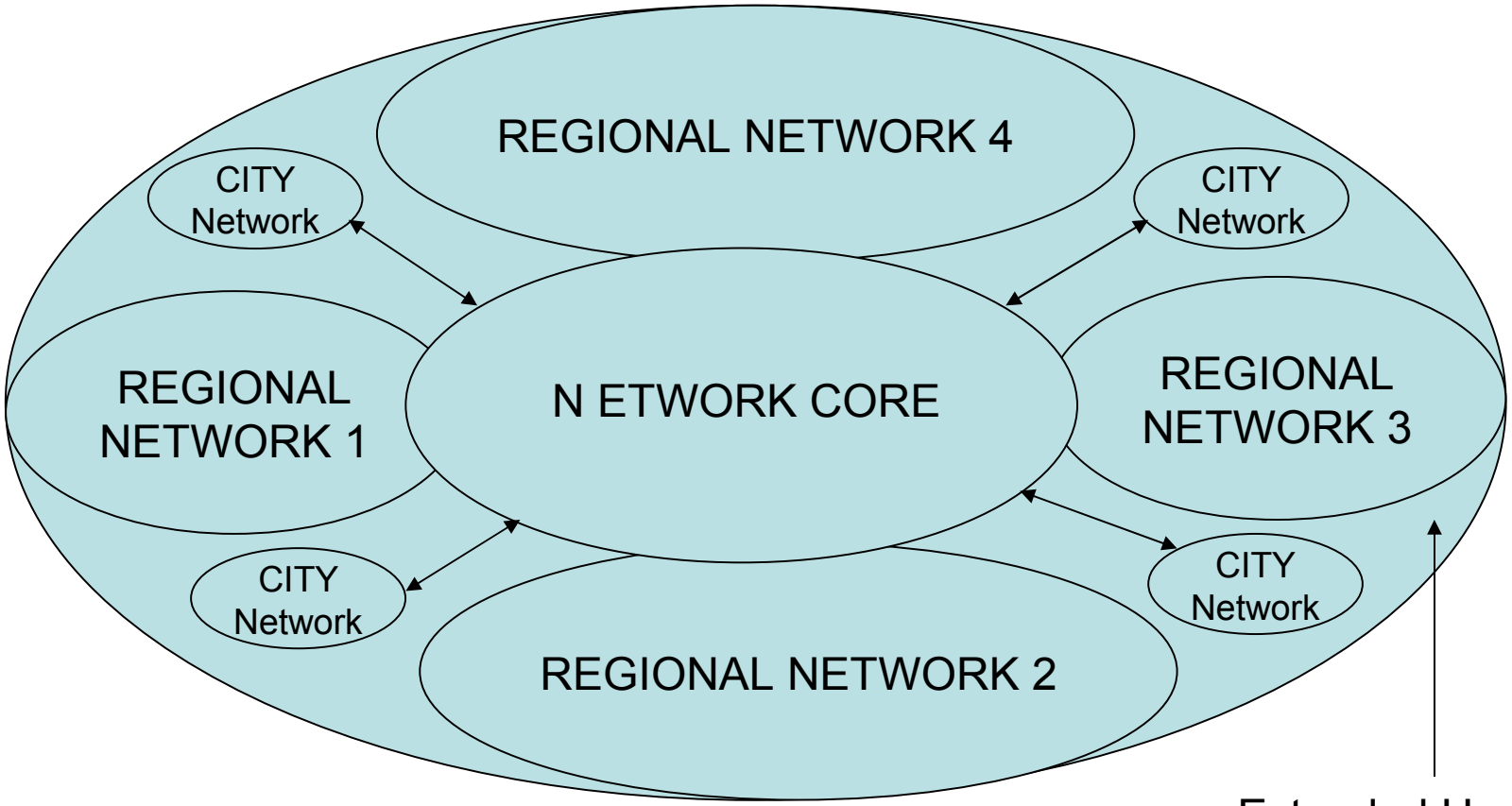
Vertical Handover



The Network Management Layer

- Defines and controls several networks
- Each network is controlled by a network operator
- Support for network virtualization and partitioning
  - Several networks managed by different network operators but on the same extended hardware platform
    - Will facilitate regional or city-wide operators

Diverse Networks on one Extended Hardware Platform



Status

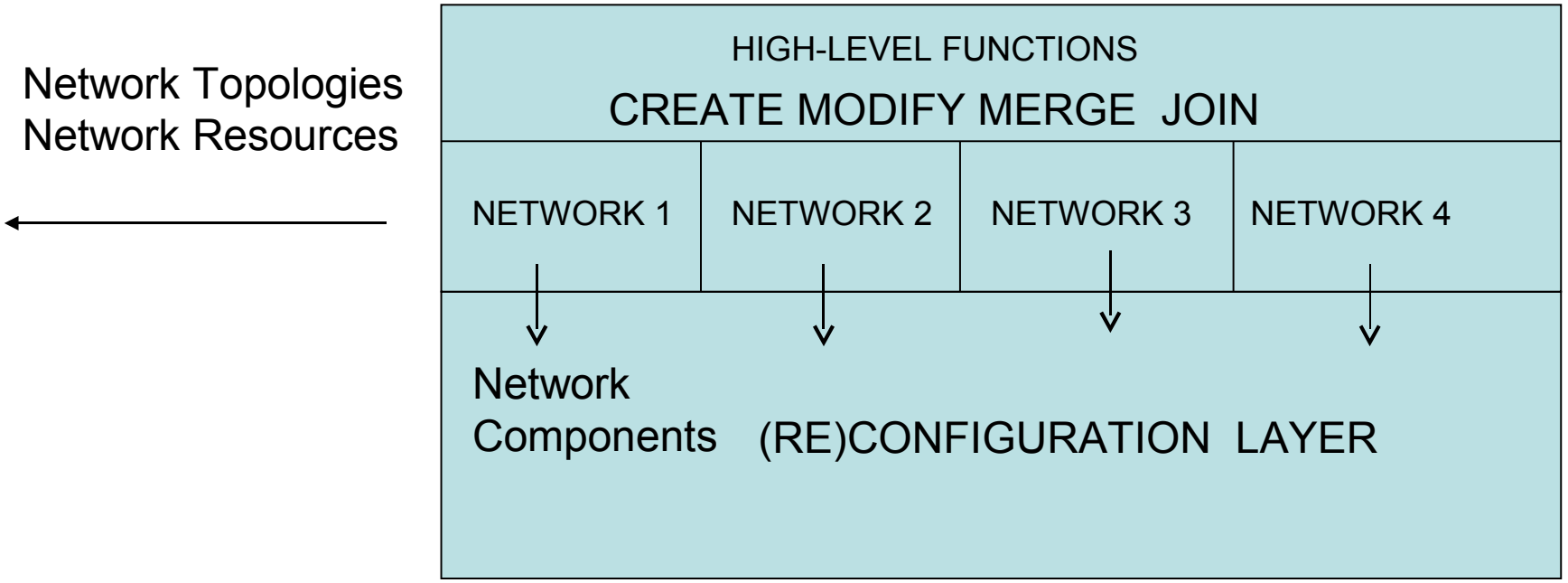
- Very few open management tools
  - OpenNMS
- Most tools are about network monitoring
  - Using SNMP
  - Unable to manage a very large network
    - Can't manage global/national network
  - Can't manage several networks in an integrated way

What we want

- Networks to be managed in a flexible way
- An interface that defines and manages an entire network in terms of programmable components, including switchlets, routelets, etc.
  - i.e. network virtualization
    - using software abstraction to control the network
- Create new networks (spawning)
- Merge and partition networks

NETWORK MANAGEMENT

Network Topologies
Network Resources



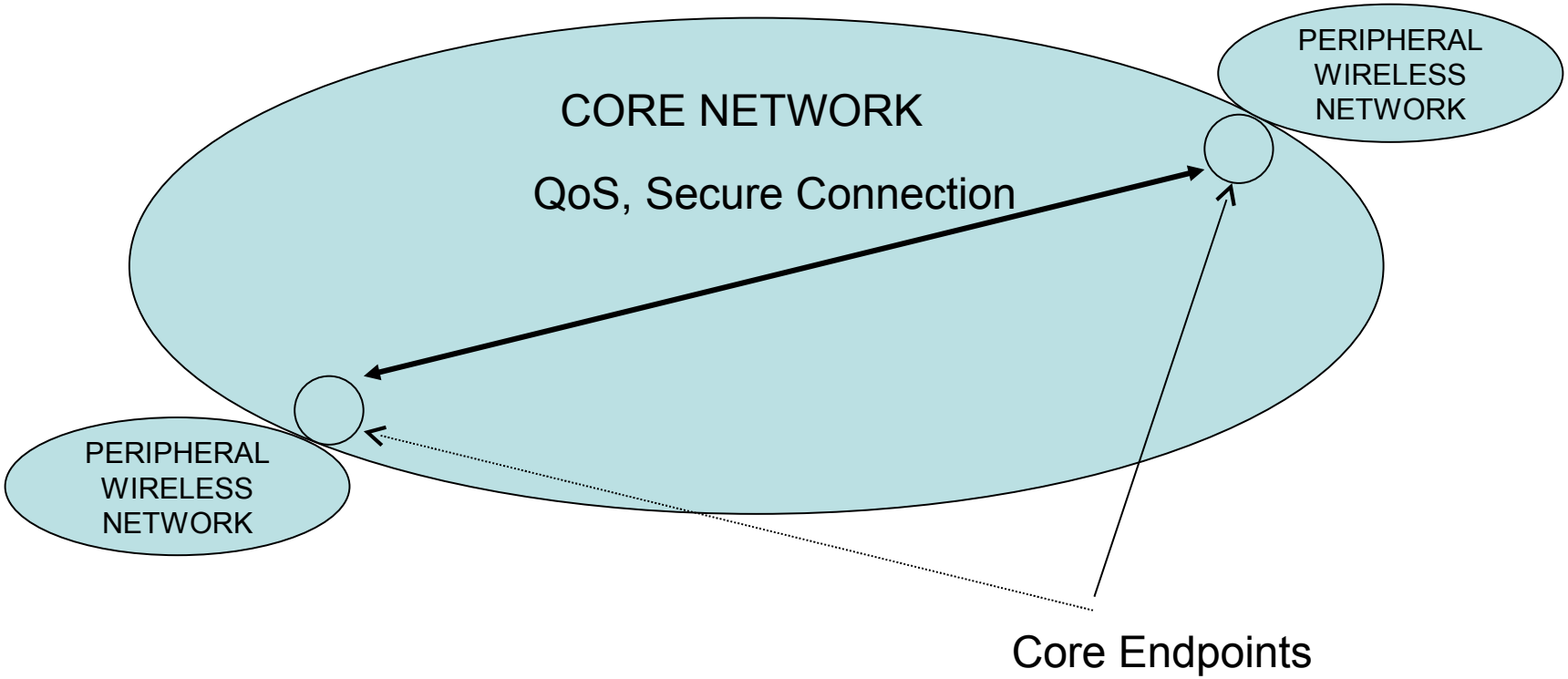
Anything Similar??

- GENESIS Project
  - Columbia University in late 1990's
- Programmable Virtual Network
  - Making networks more programmable
  - Key operations
    - Spawning, Profiling and Management
    - Virtual Network Controller
    - Virtual Network Manager
  - Didn't get very far – funding dried up

Core Transport System

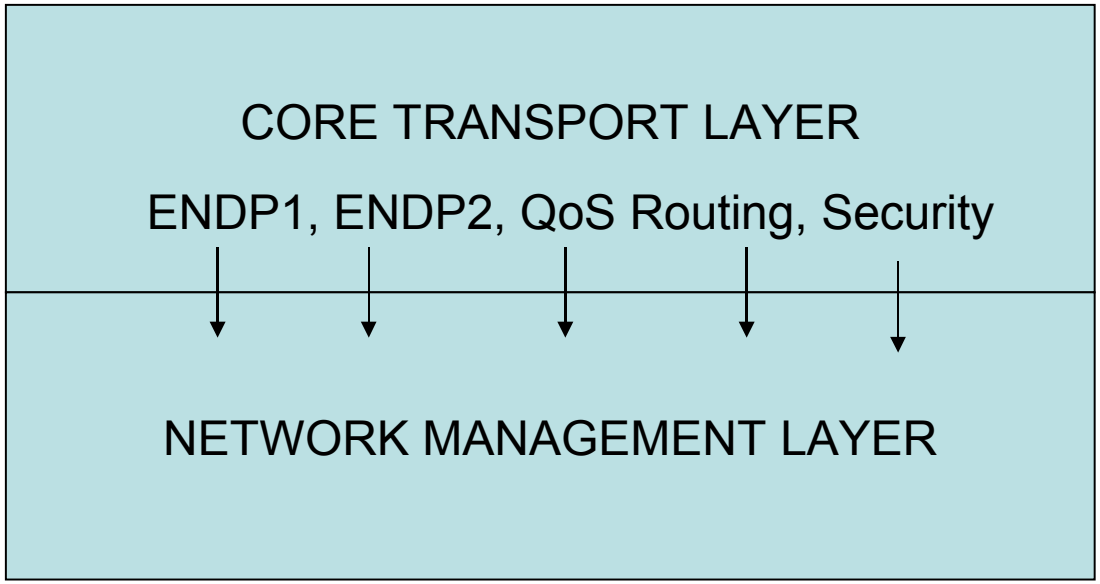
- Concerned about moving data between points in the core network
- TCP/IP is the Transport and Network protocols for the Internet
- Migration of IPv4 to IPv6
  - Important for the new frameworK
  - Need enhancements
    - Easier mechanisms to support security
      - VPNs, Tunnelling, etc

Core Transport in Y-Comm



Core Transport: Making Connections between Core Endpoints

Make connection Between Wireless Networks

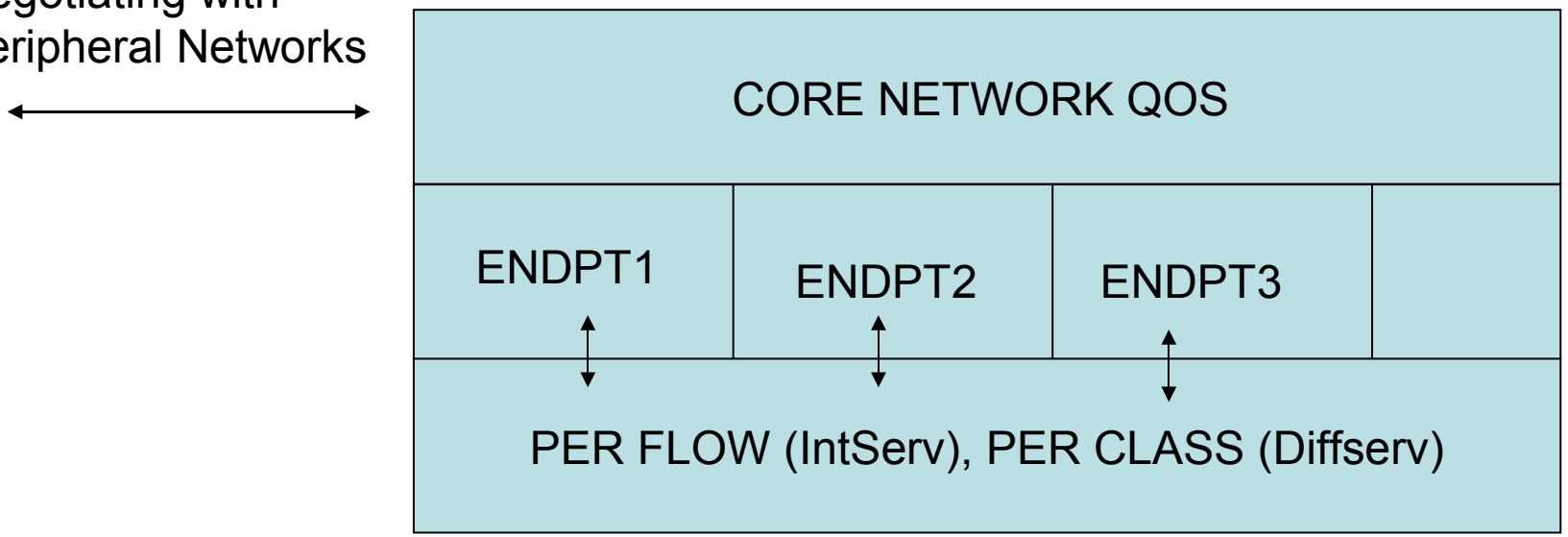


Network QoS Layer

- Current QoS models
  - IntServ
    - Largely abandoned
  - DiffServ
    - Slow deployment
- Need to explore network QoS models
  - Negotiation structure between Core Network and Peripheral Networks

Enhance QoS Functionality

Negotiating with Peripheral Networks



Service Platform

- Services developed by third parties
- Should be able to configure services on several networks at the same time
- Support for installing services for specific types of networks
  - London travel service available to networks around London

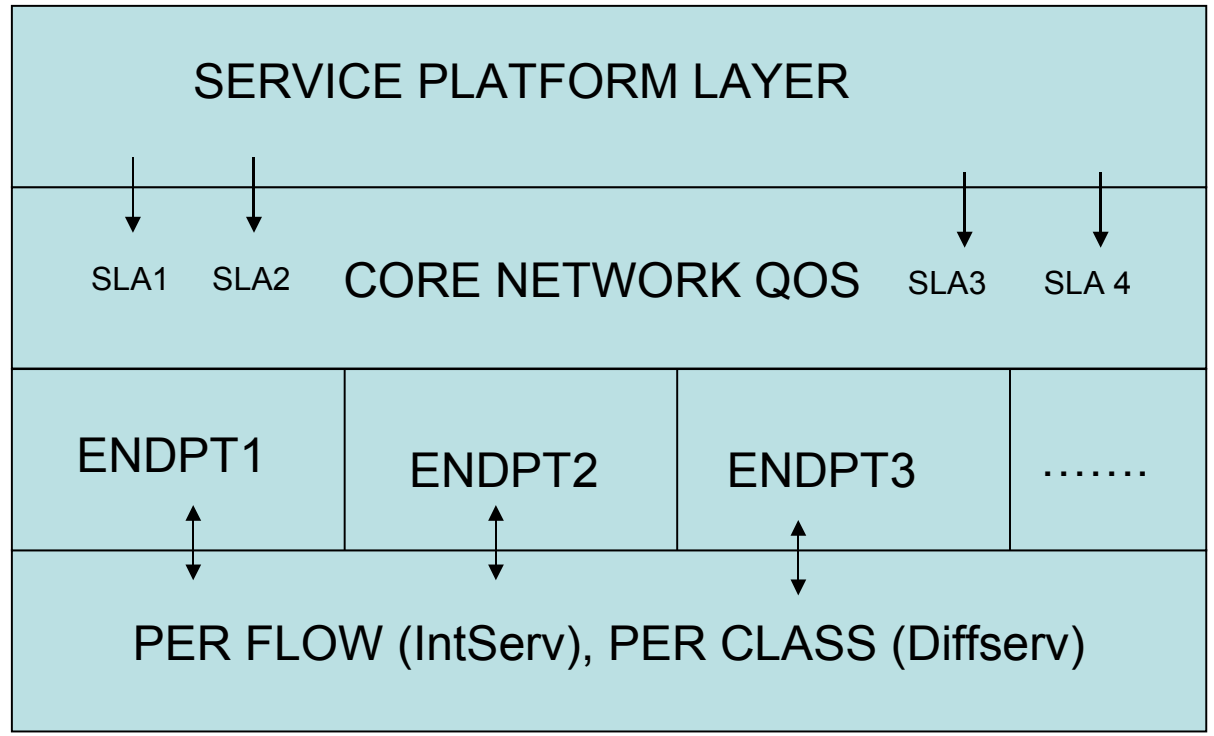
SERVICE PLATFORM LAYER

- Installation
  - Install over many networks simultaneously
  - Specifying QoS (minimum SLA)
- Server Advertisement and Subscription
- Session management
  - Interaction between server and application running on the mobile node
- Supporting Mobility
  - How is QoS maintained even though the mobile is moving
    - Server replication, proxy server support

Service Platform and Core Network

Server Advertisement
Subscription
Applications

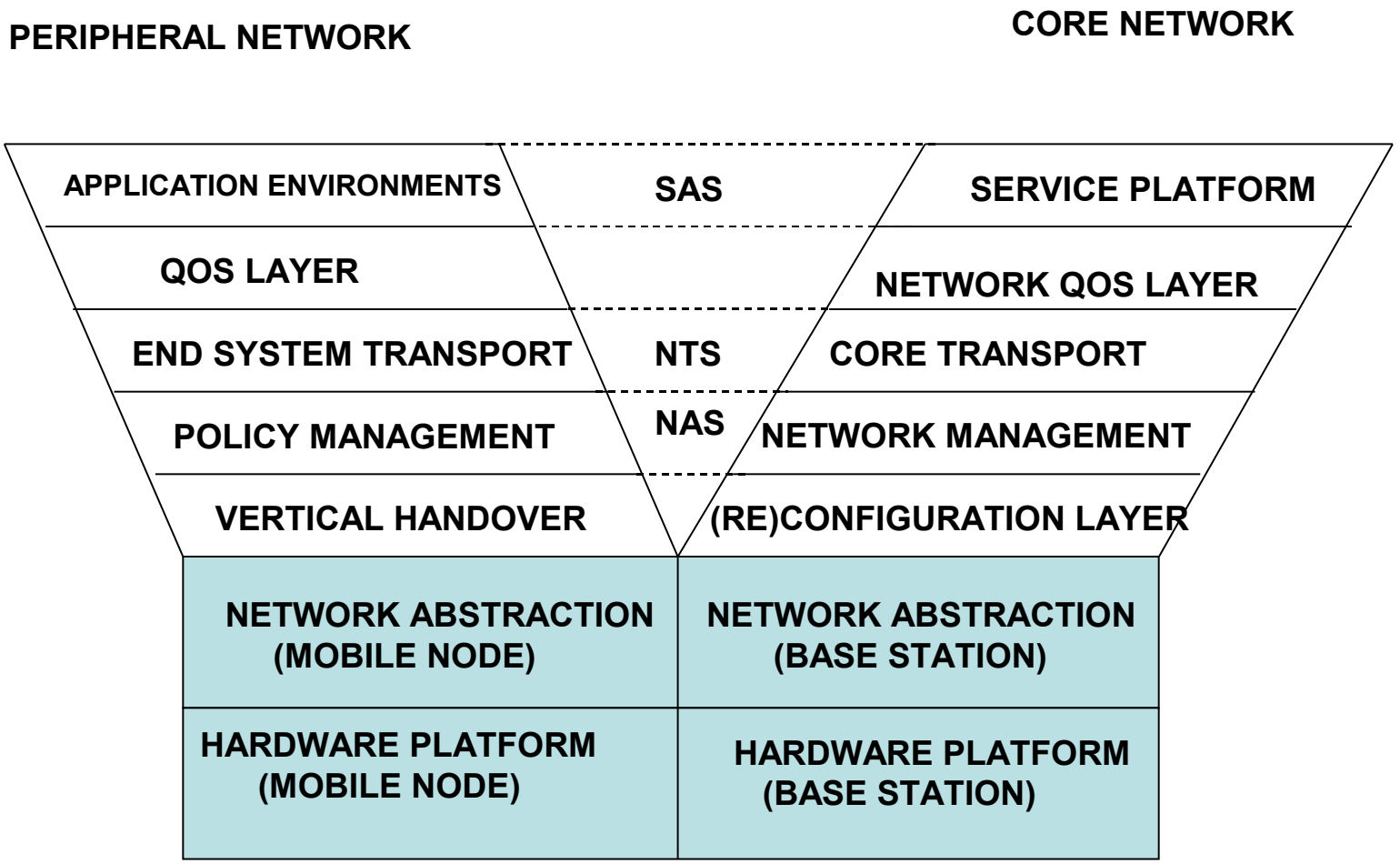
Negotiating with
Peripheral Networks



Need to Address Security

- Cannot be a separate Layer in the architecture as there are different kinds of security issues
- Y-Comm defines a 3-layer security architecture
- Comprehensive Design
  - Security system is integrated into the structure of Y-Comm

The Y-Comm Framework showing its Security Levels



Security in Y-Comm

- Network Architecture Security (NAS)
  - Security dealing with the deployment and management of different wireless technology
  - Managed from the Policy and Management layers
- Network Transport Security (NTS)
  - Security dealing with end-to-end transport through Y-Comm
  - Done at Layer 5, NAT, IPSec, etc
- Service and Application Security (SAS)
  - Security dealing with running applications and deploying services
    - AAAC, ACLs, User-based security

Security Model: Another layer

- Security Layer at QoS Layer
- Qos Security (QoSS)
  - Security should be viewed as part of QoS
  - Changes in security should be viewed as changes in QoS
- Other issues:
  - Prevent overloading of endpoints
    - Mobile changing points of attachments due to vertical handover
    - Migration of proxy servers to different networks

Another Layer- QoS-based security (QBS)

- Key Issues
  - You might compromise the security of a network by trying to satisfy SLAs
    - Install a server or proxy server which has a lower security profile than the network that you want to use to migrate the service.
  - Monitor SLAs, so can be used to detect Denial-of-Service (DoS) attacks

The Y-Comm Framework showing its Security Levels- New Security Level