Autonomic Networking and Virtualization

Application to the wireless Internet

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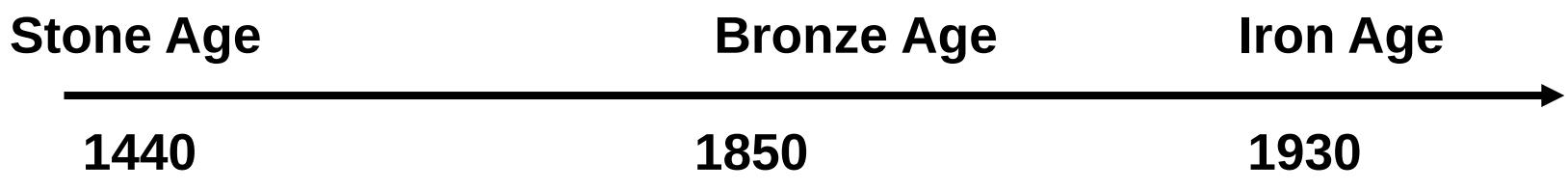
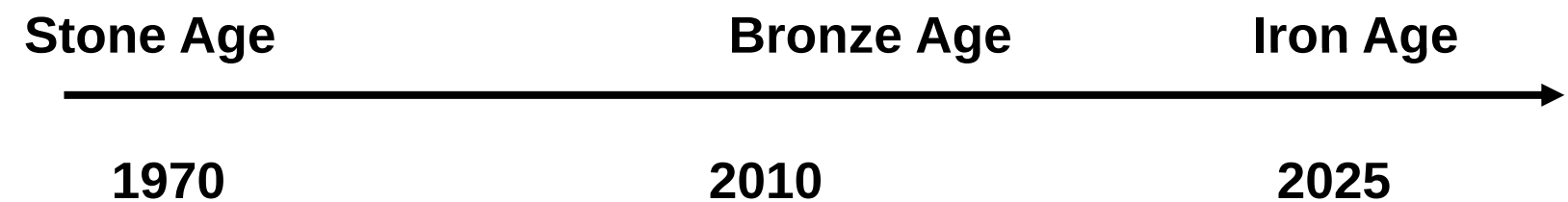
Age

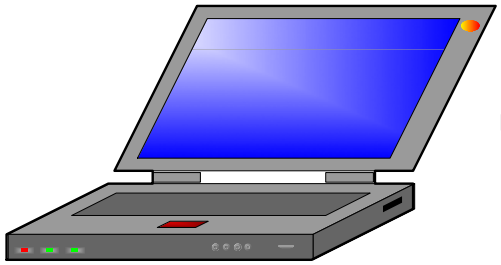
Printing

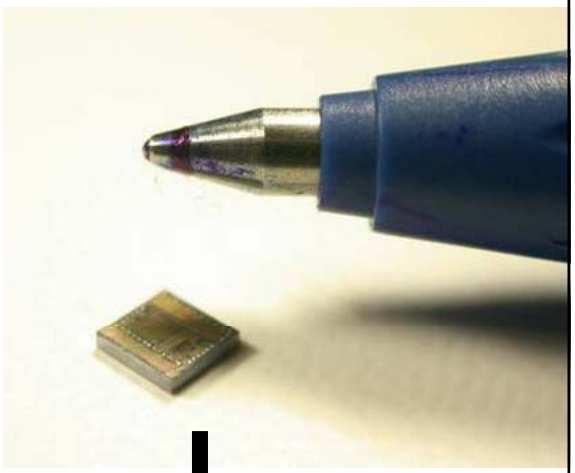


Internet



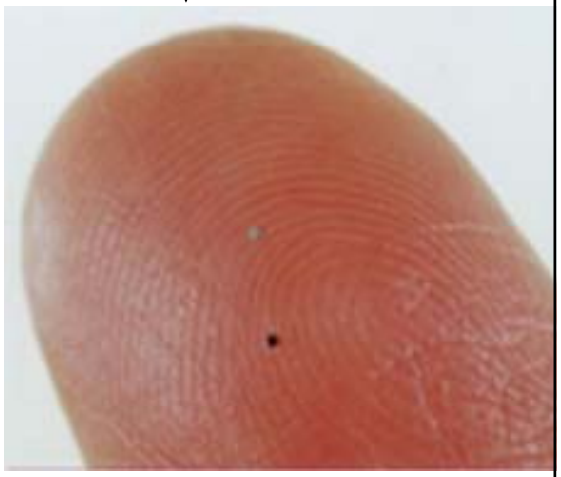
Evolution of Networks





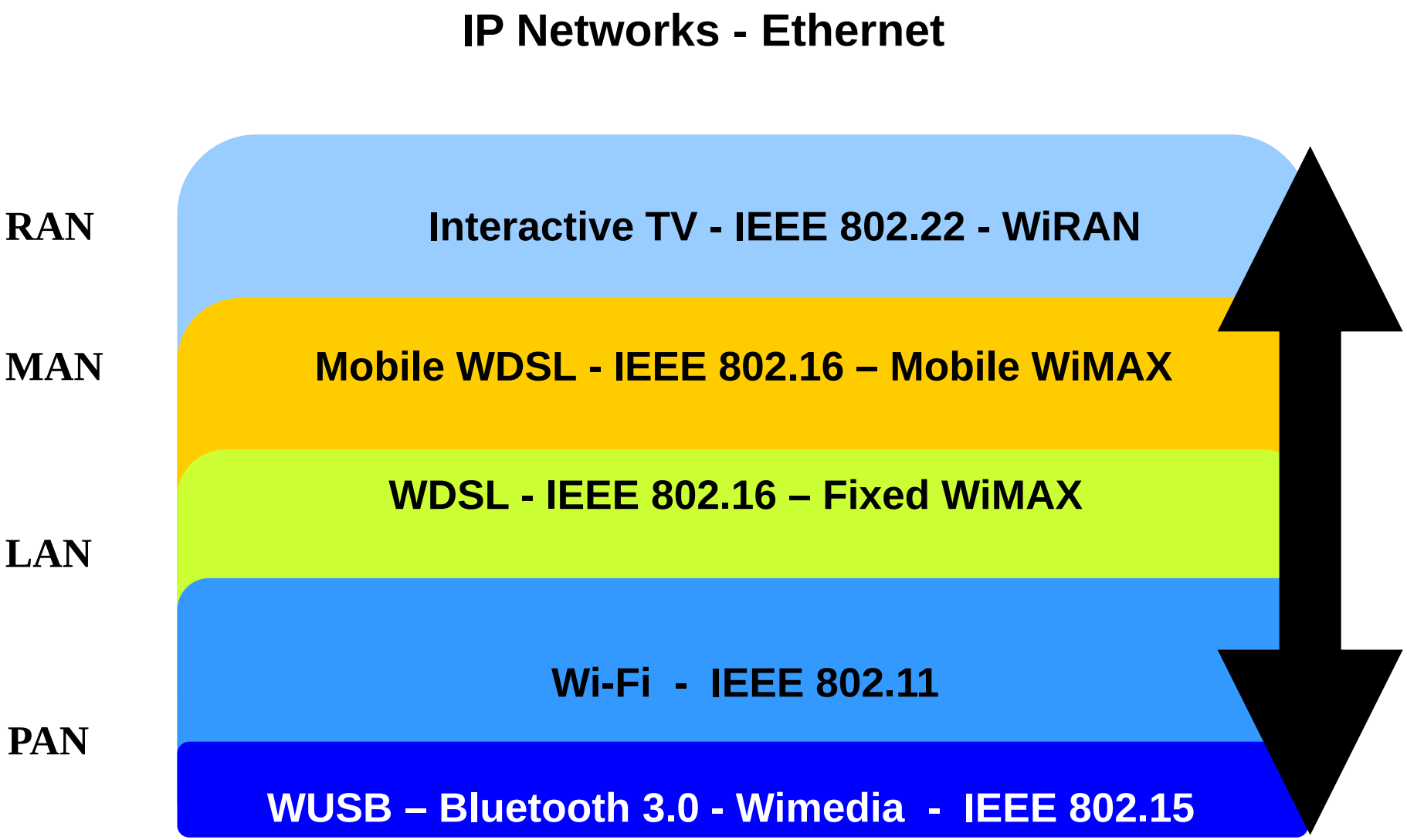
Internet

Protocol

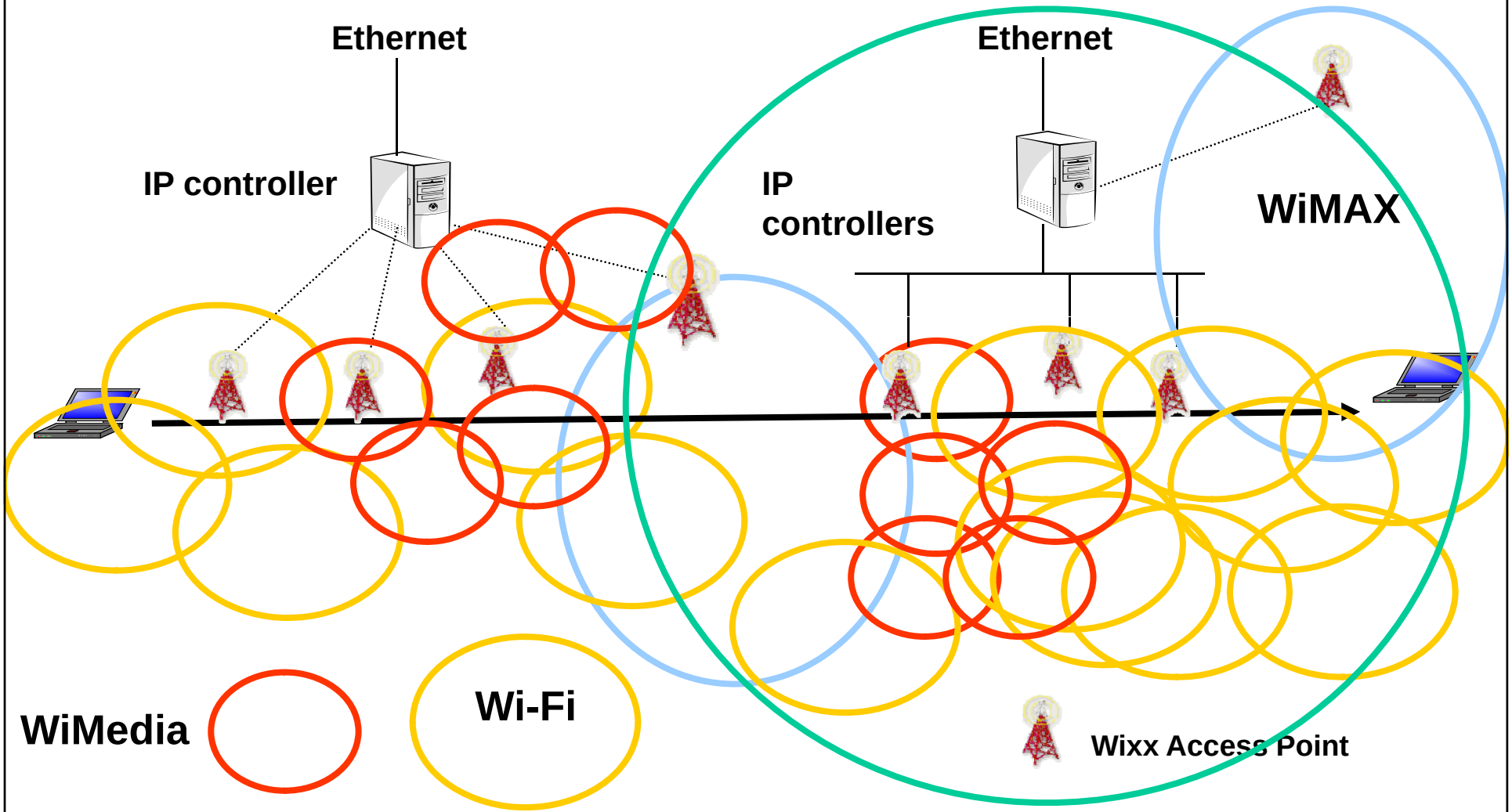


Wireless Internet

Wireless Networks



Wireless Internet



Autonomic Networks

Complexity

- Networks keep moving towards ever increasing complexity
- New services added every week!
  - New technologies added every month!
  - New architectures introduced every year!
  - Combining the old with the new (no replacement!)

Complexity

- **Where are "ever increasingly complex" networks heading?**
  - Something needs to be done ...
  - Open systems people need to do something ...
- **Solution: introduce an autonomic behavior to provide an automatic configuration.**

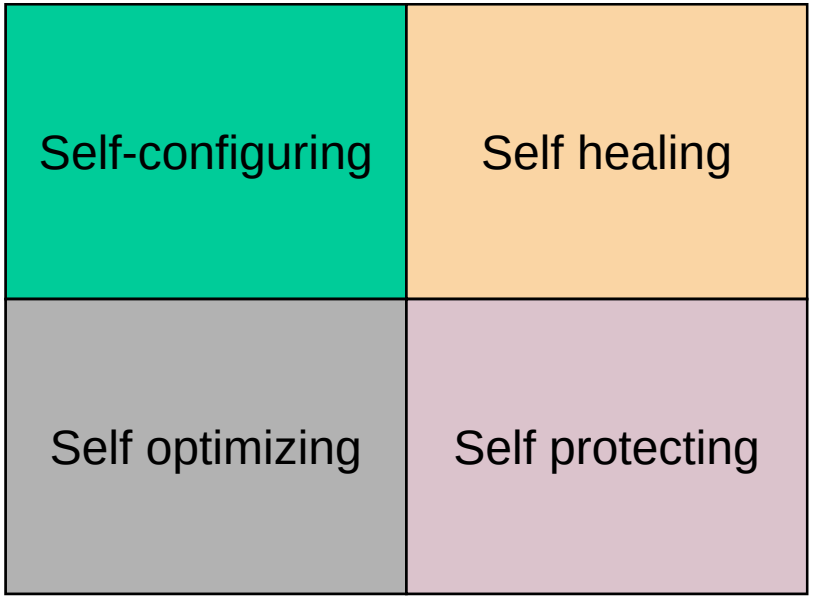
Autonomic networking

Increased responsiveness

Adapt to dynamically changing environments

Business resiliency

Discover, diagnose, and act to prevent disruption



Operational efficiency

Tune resources and balance workloads to maximize use of IT resources

Secure information and resources

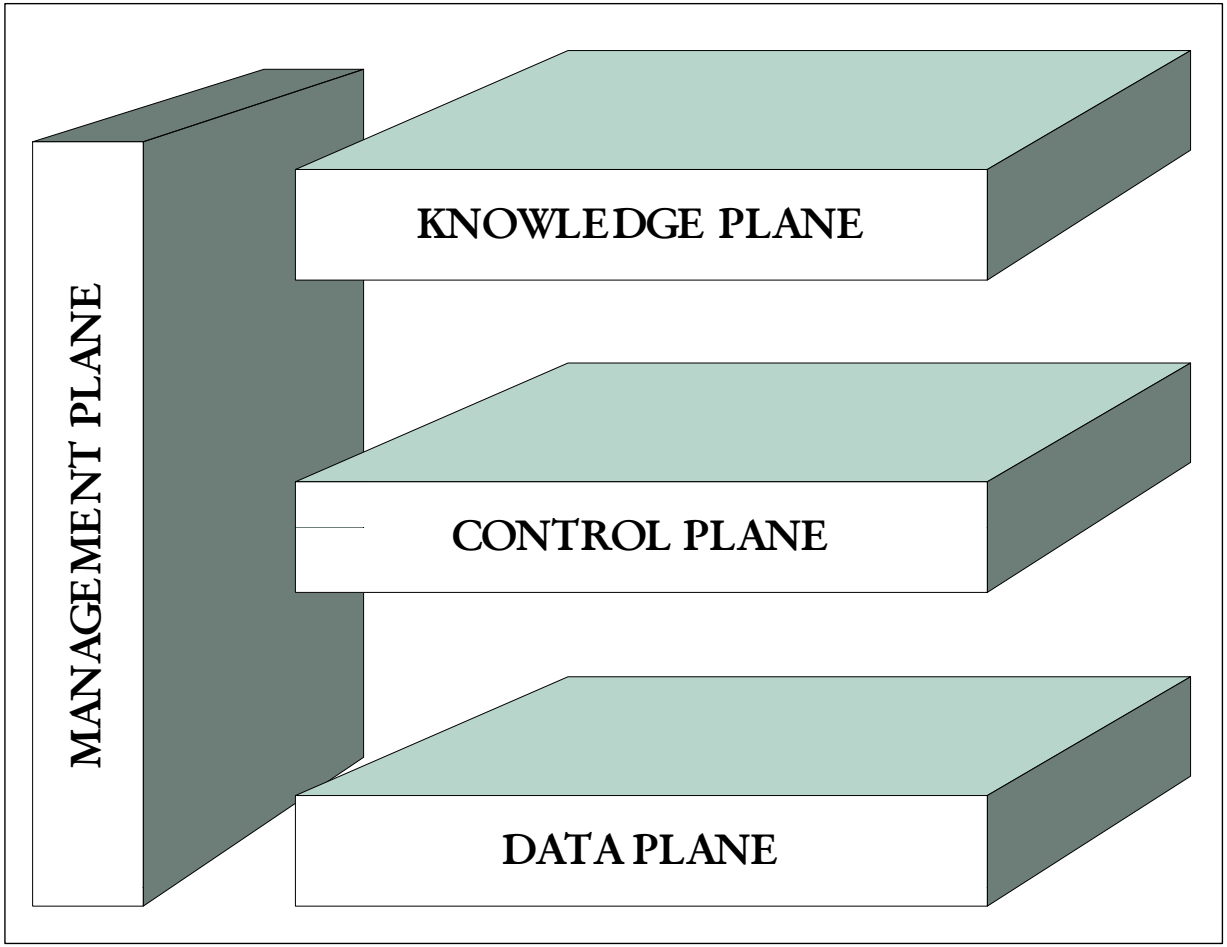
Anticipate, detect, identify, and protect against attacks

A new plane

- **Knowledge plane**
  - Situated view on the network
- **Configuration plane**
  - An intelligence is needed to pilot the network
  - Configure the control algorithms
- **Information plane**
  - Proposed in IEEE 802.21
- **Governing plane**
  - ACF (Autonomic Communication Forum)
- **Piloting plane**
  - Ginkgo Networks

A new plane: ACF

- The knowledge plane



A new plane: Ginkgo Networks

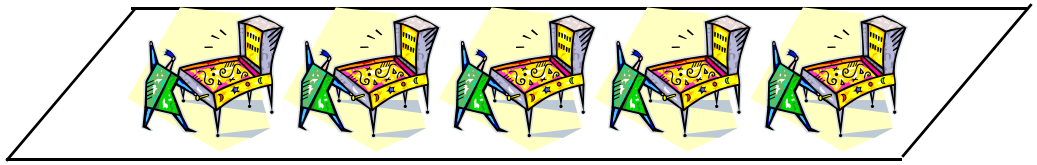
Management Plane

Piloting Plane

Situated decision

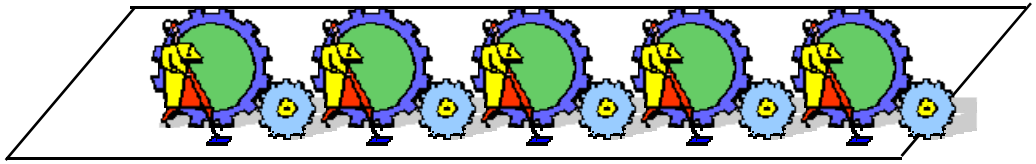
Control plane

Control algorithms

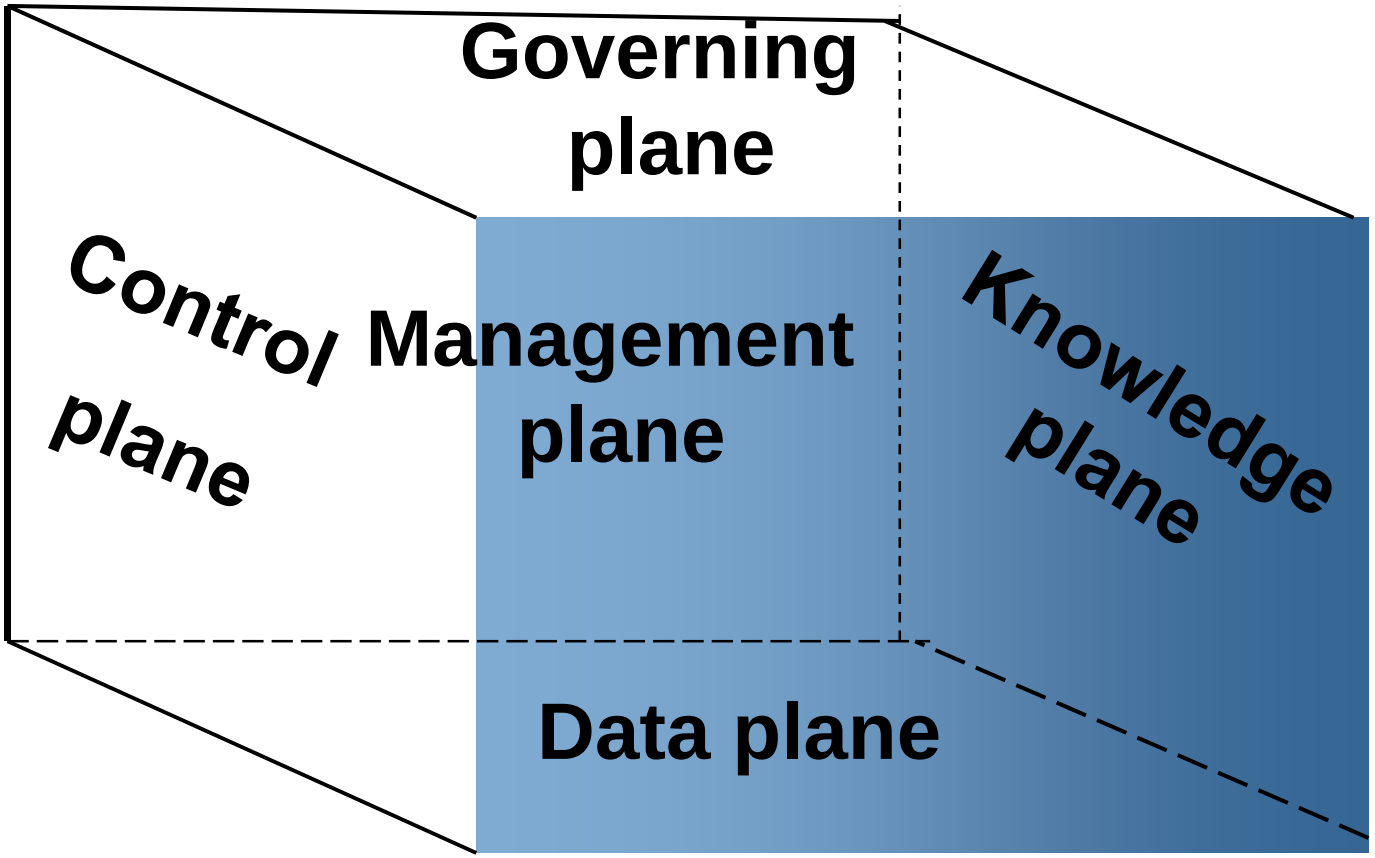


Data plane

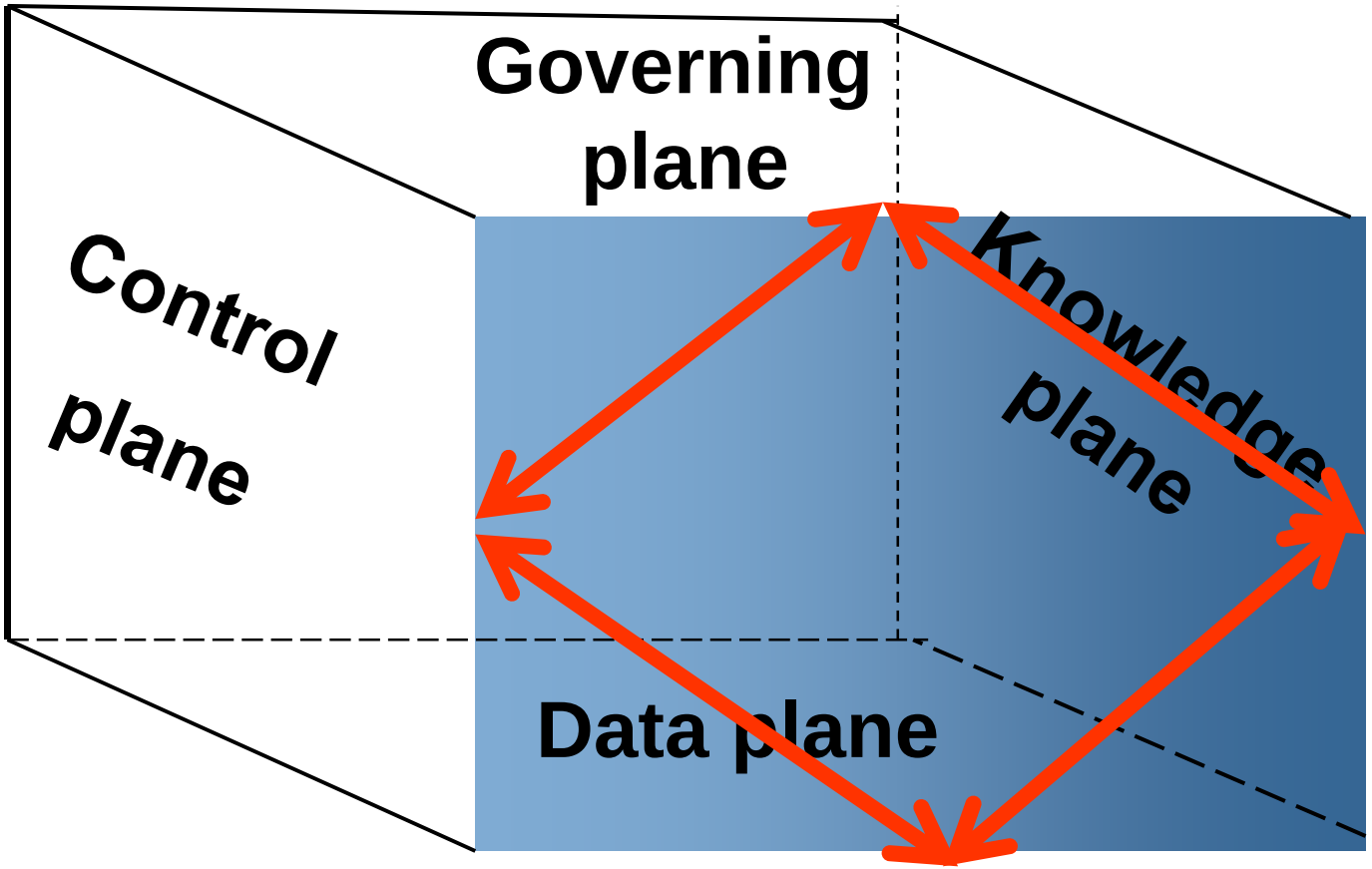
Networks elements



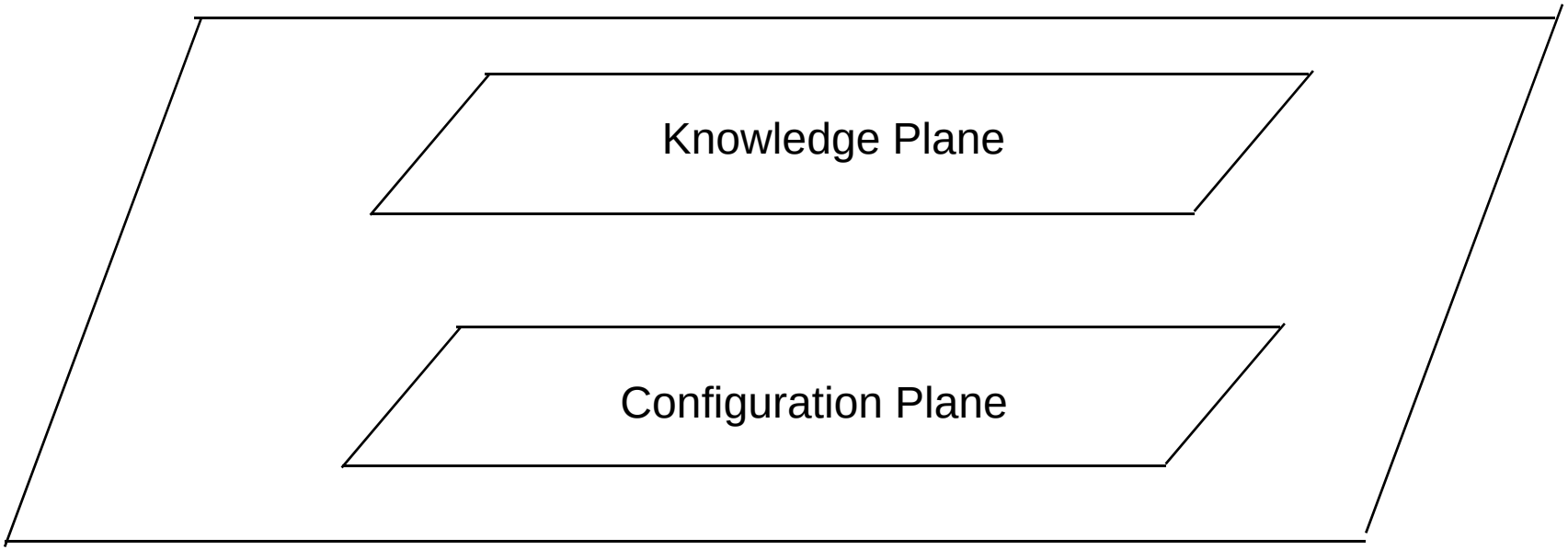
New architecture



New architecture

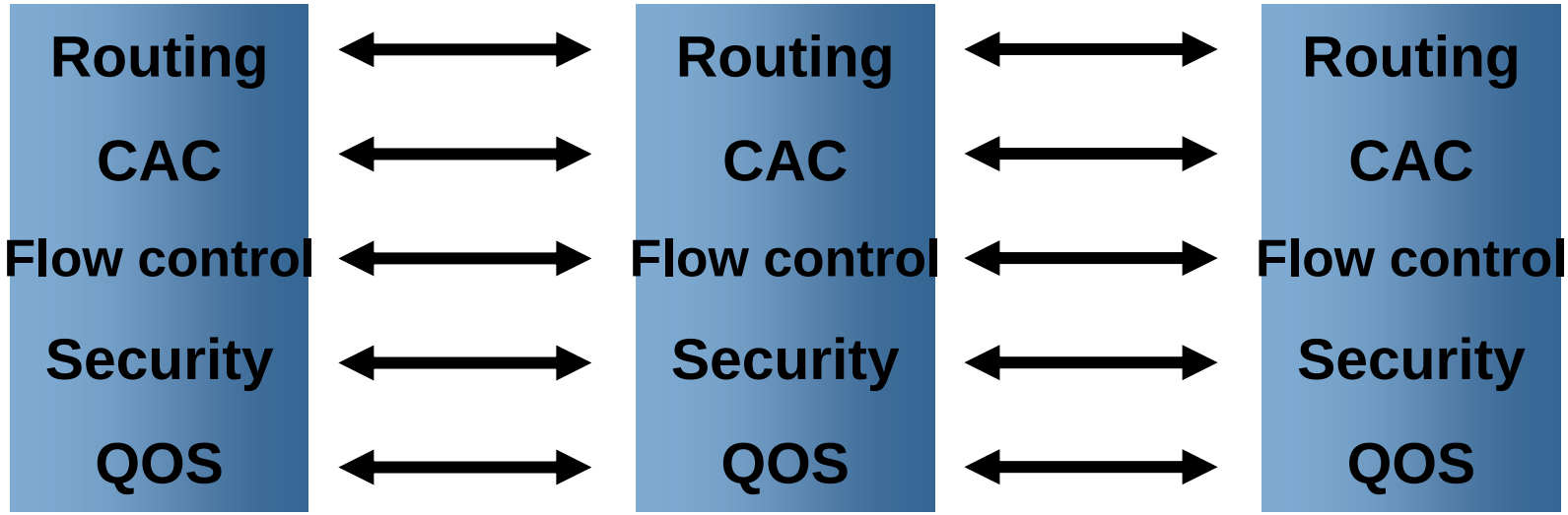


The Piloting plane

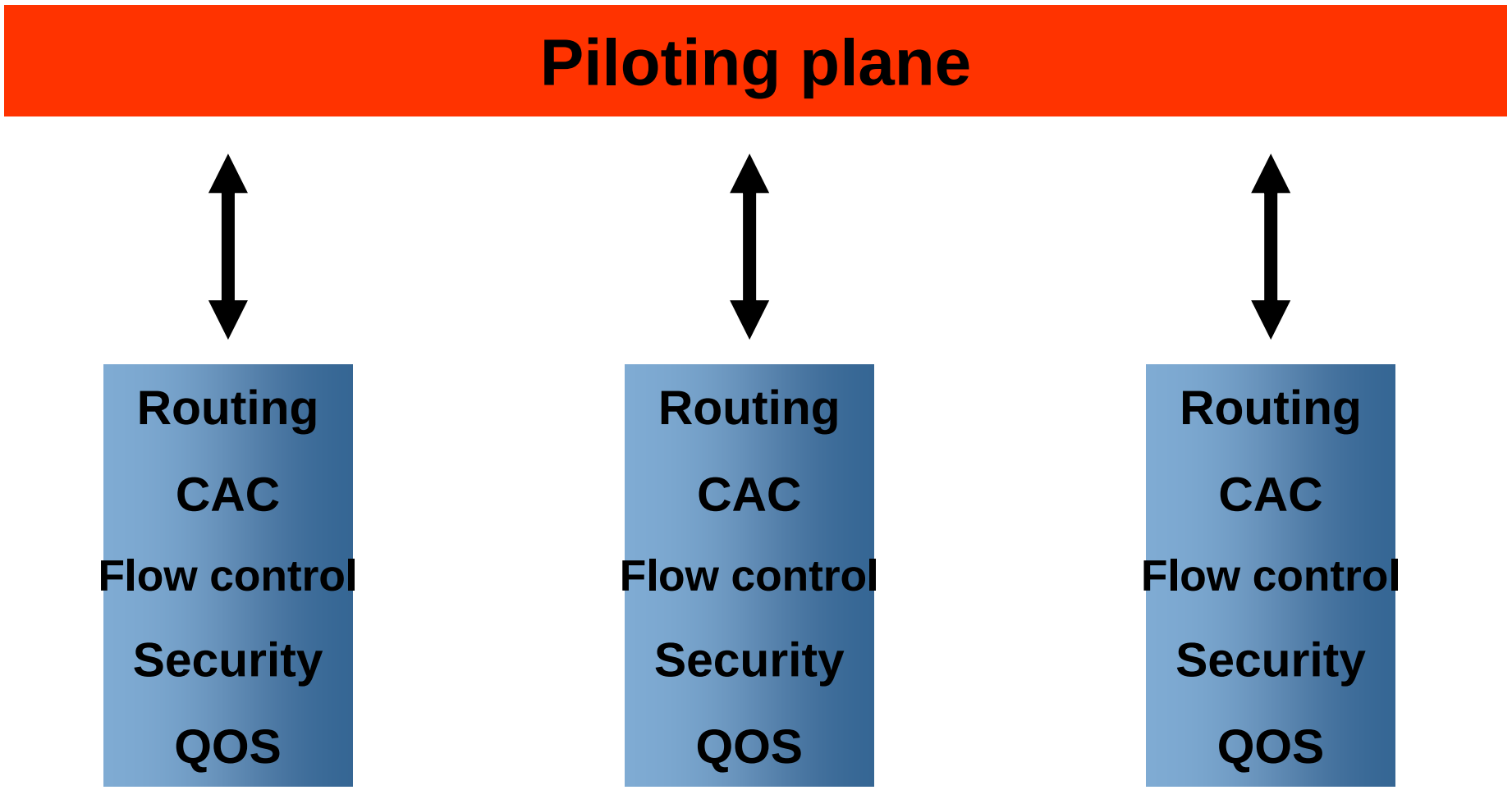


Without a Piloting Plane

Today



With a Piloting Plane



Tomorrow

Autonomic communications

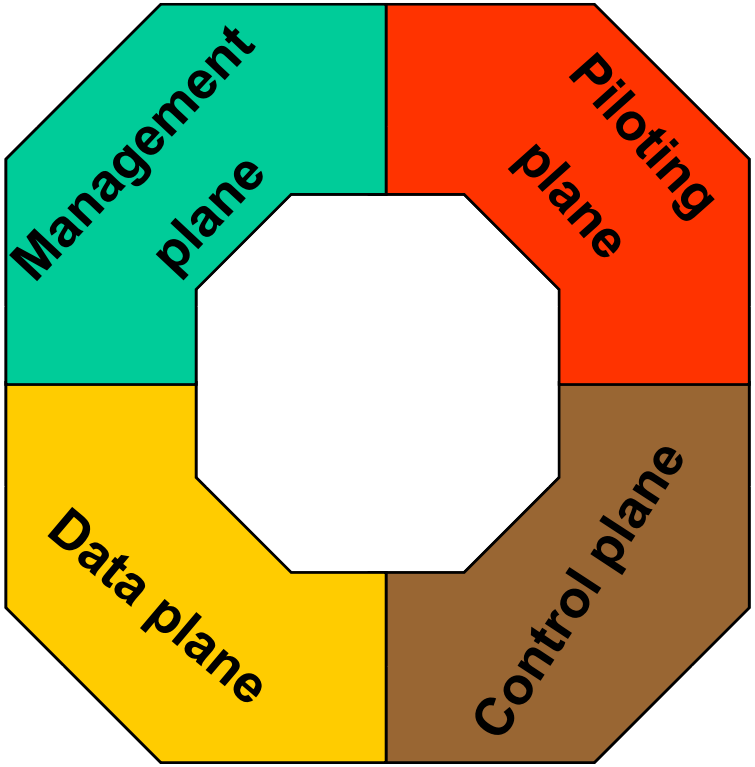
- **New generation of protocols**

Routing
QoS
Security
etc.

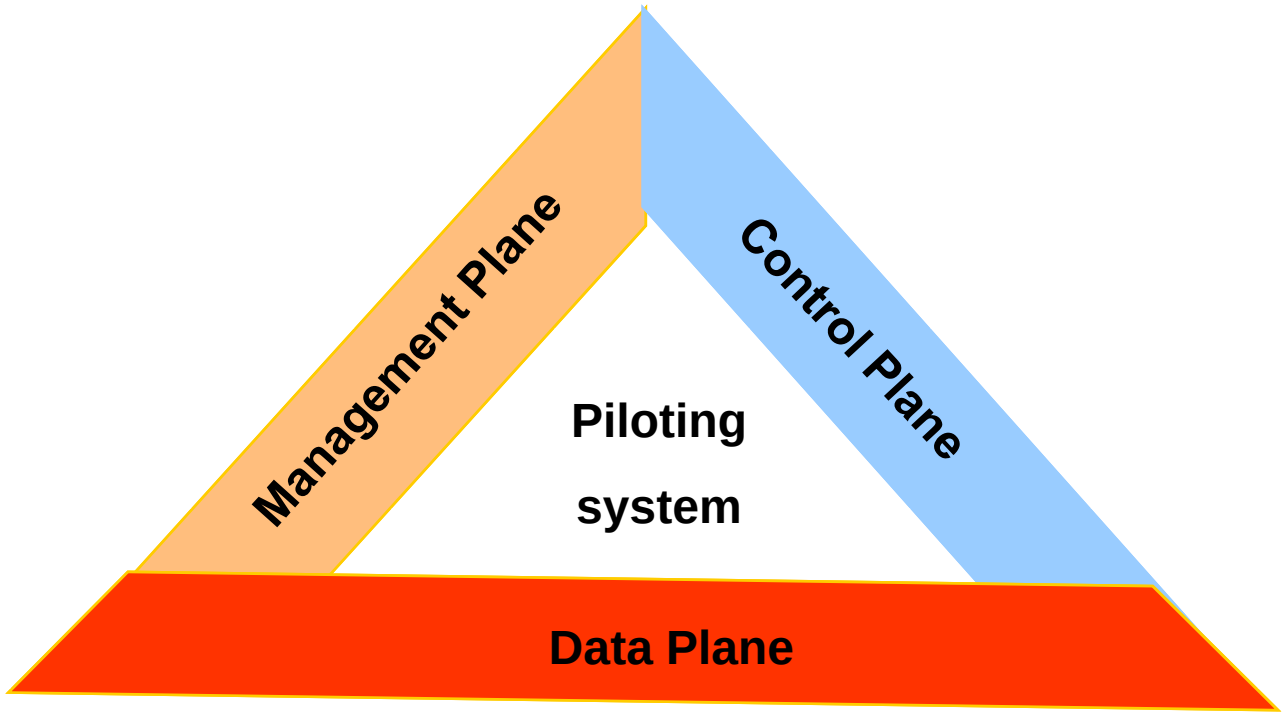
} Common knowledge

- **Which knowledge?**
  - **All the knowledge is not realistic (fresh information)**
  - **Situated knowledge**

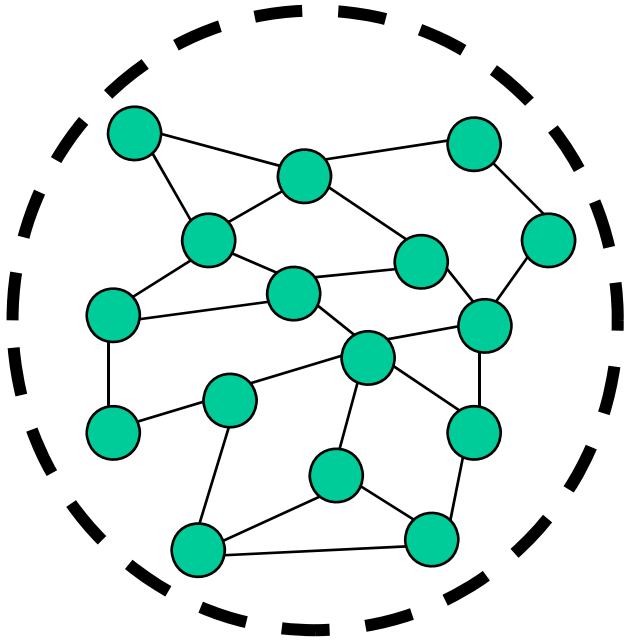
Autonomic architecture



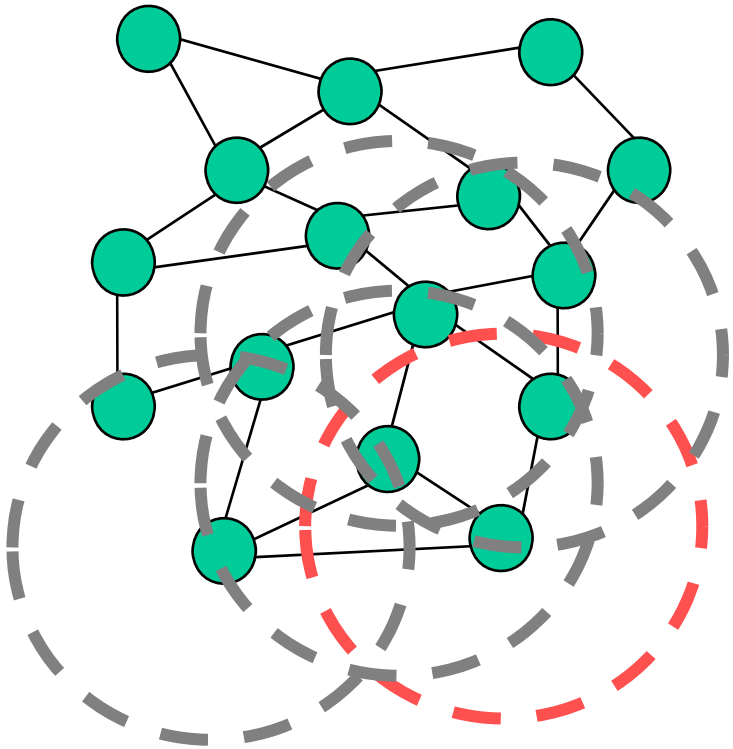
Autonomic architecture



Knowledge: Situated view



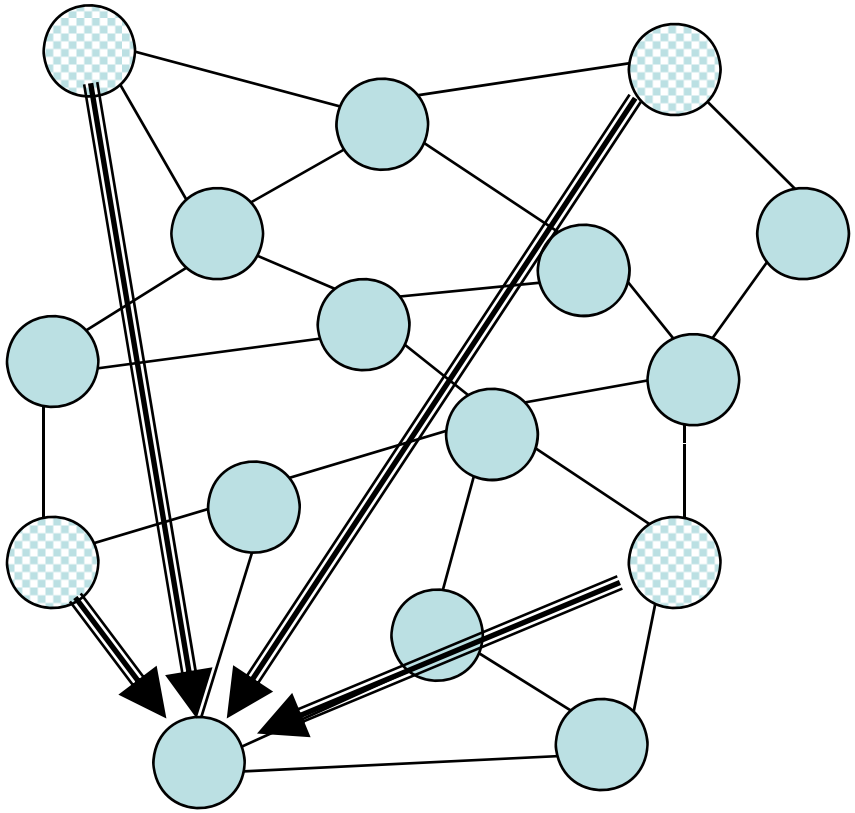
Global knowledge



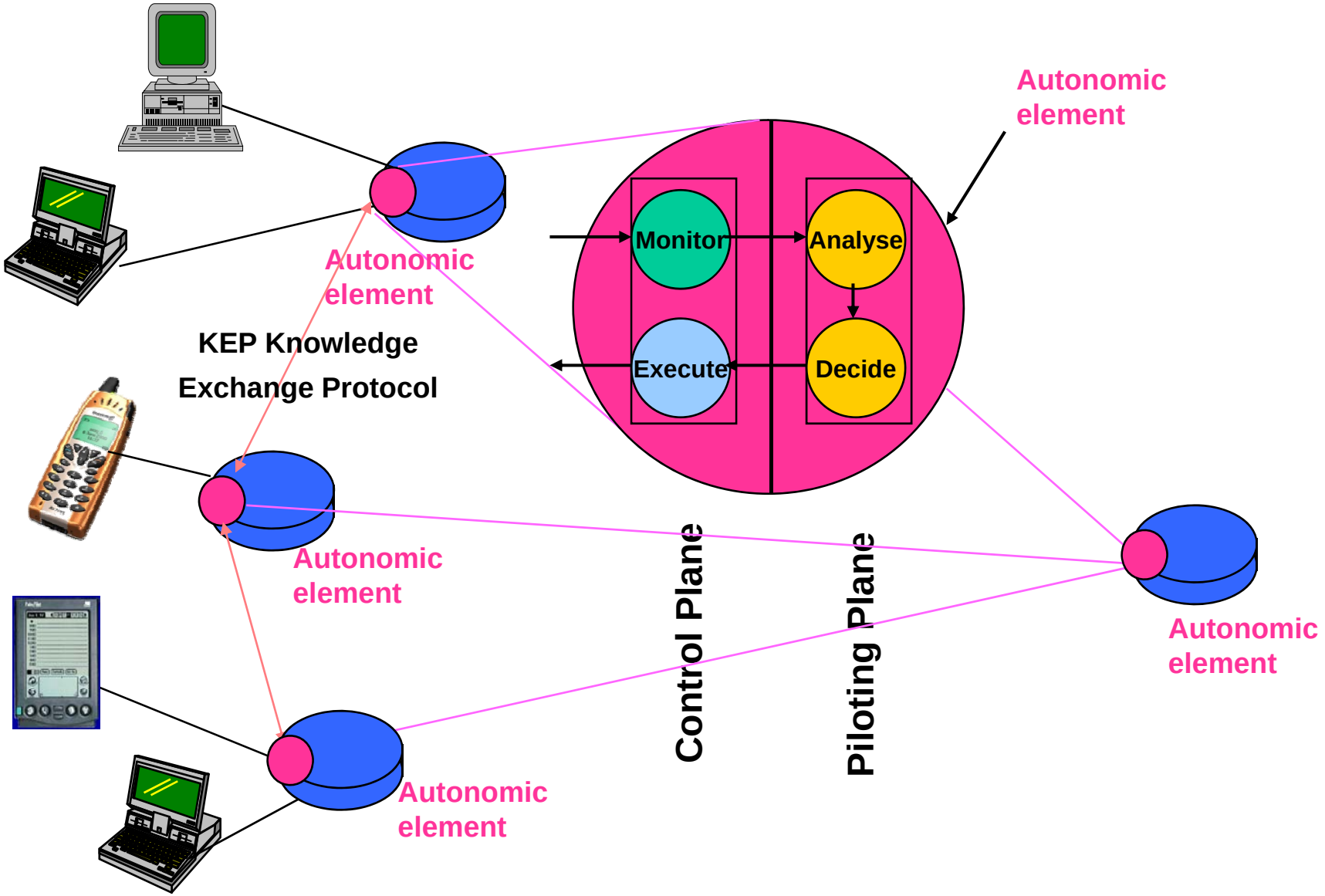
Situated knowledge

Each Agent has its own Situated View of the Network.

Knowledge: Virtual situated view



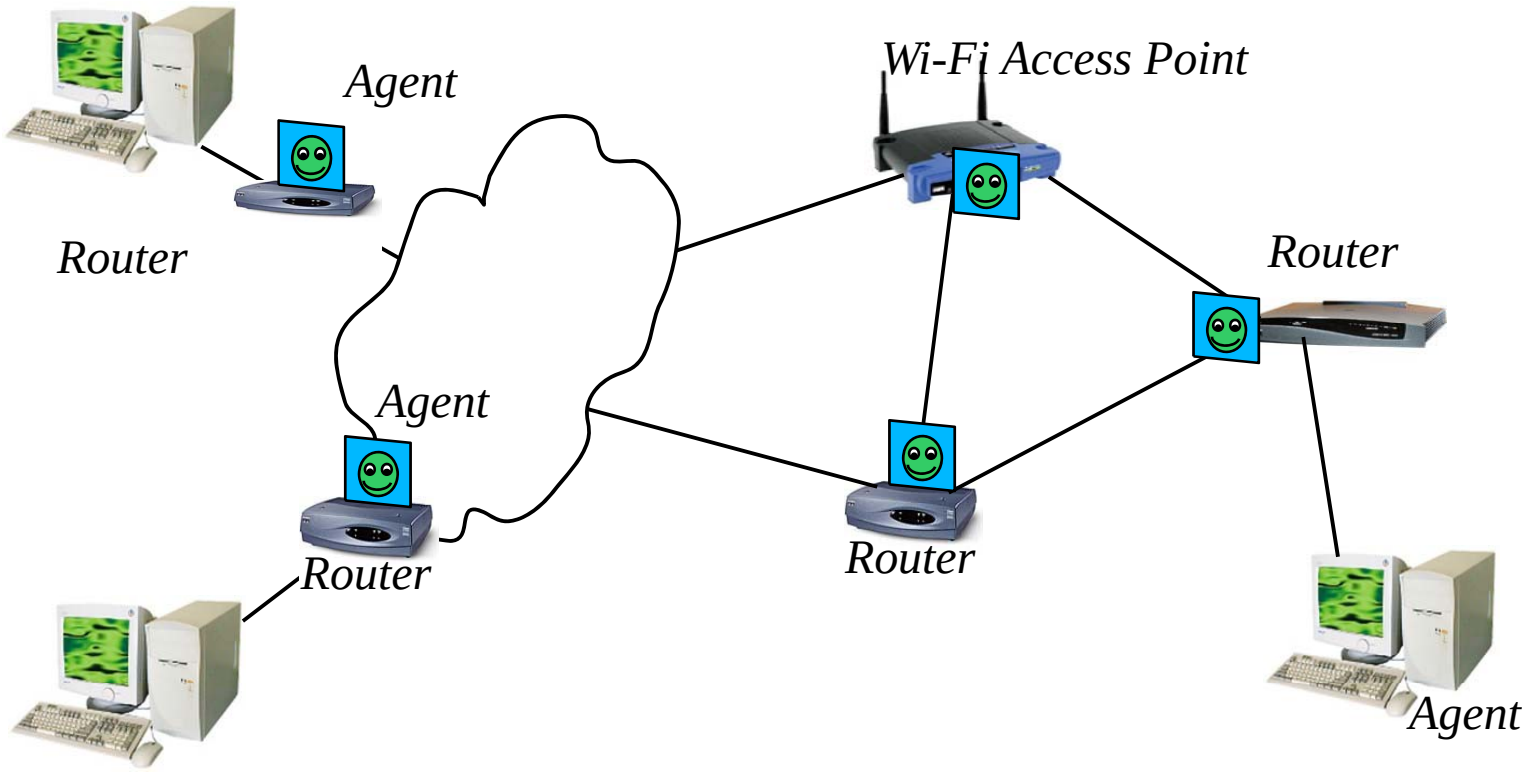
Piloting architecture



Implementation

- **Tool**
  - Distributed intelligent agent system
- **Testbed**
  - Routing
  - DiffServ Configuration
  - Home Networking
  - Wireless Internet

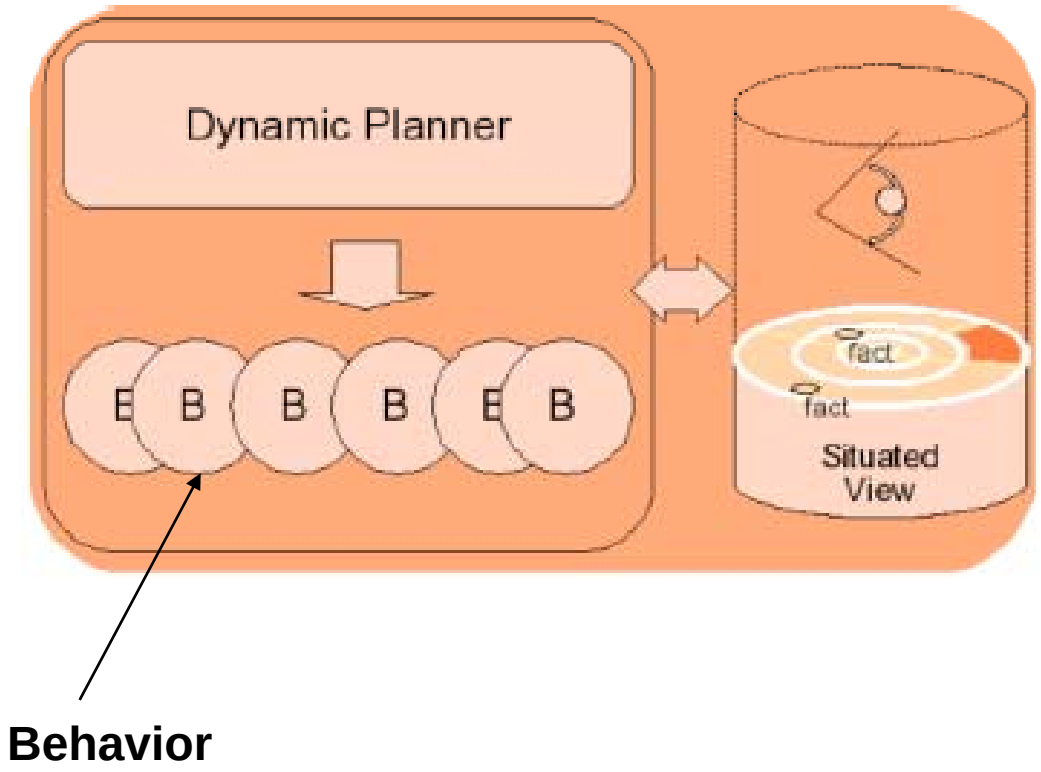
Piloting plane (Ginkgo Networks)



Distributed Intelligent Agent System

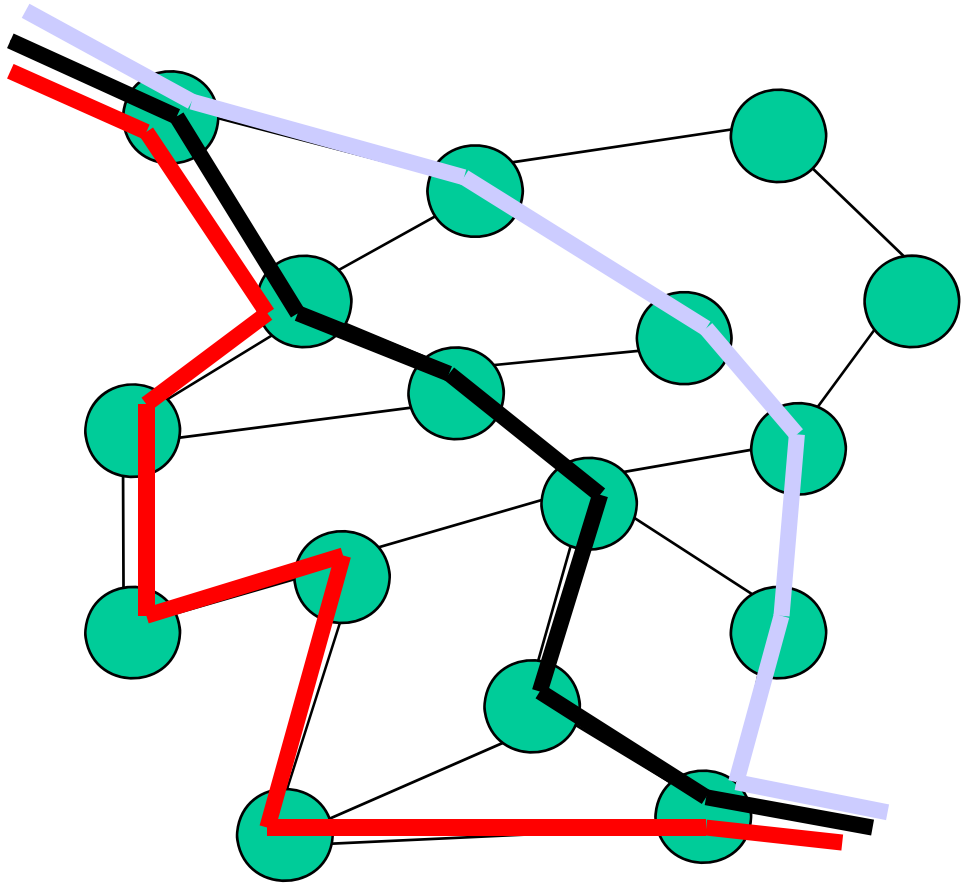
Ginkgo Networks
Next Step in Networking

Ginkgo Networks Agent



Routing

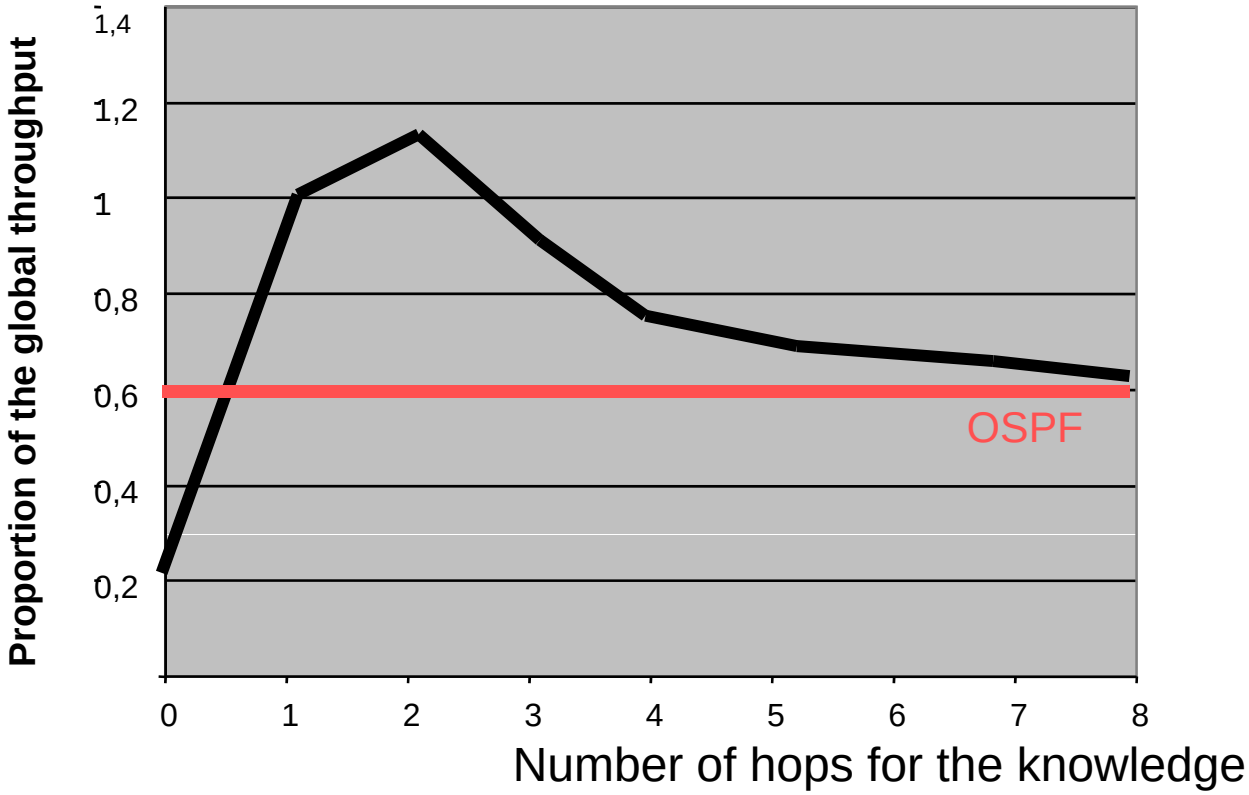
OSPF



OSPF + situated view

Measurement results

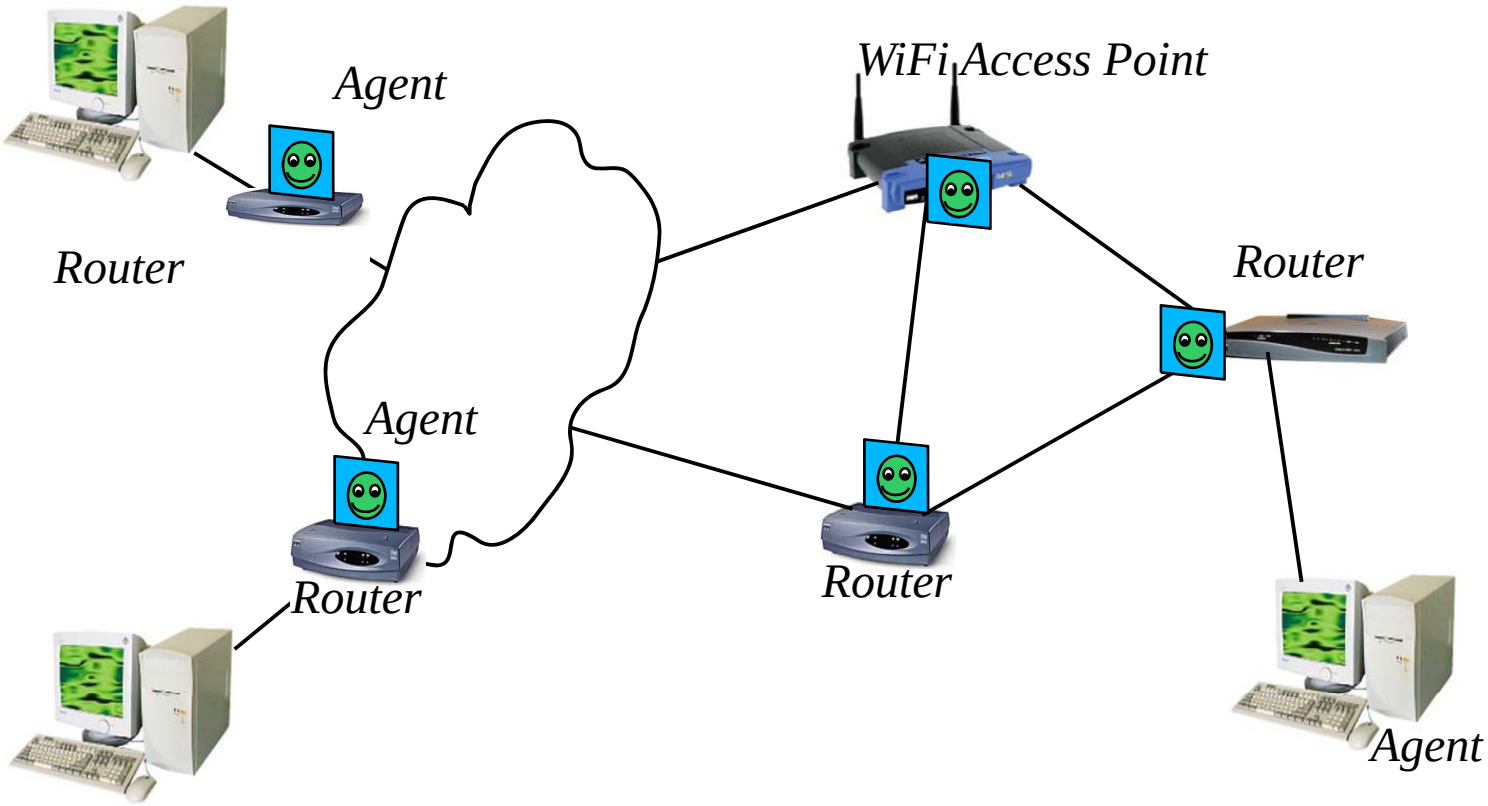
Global throughput with OSPF



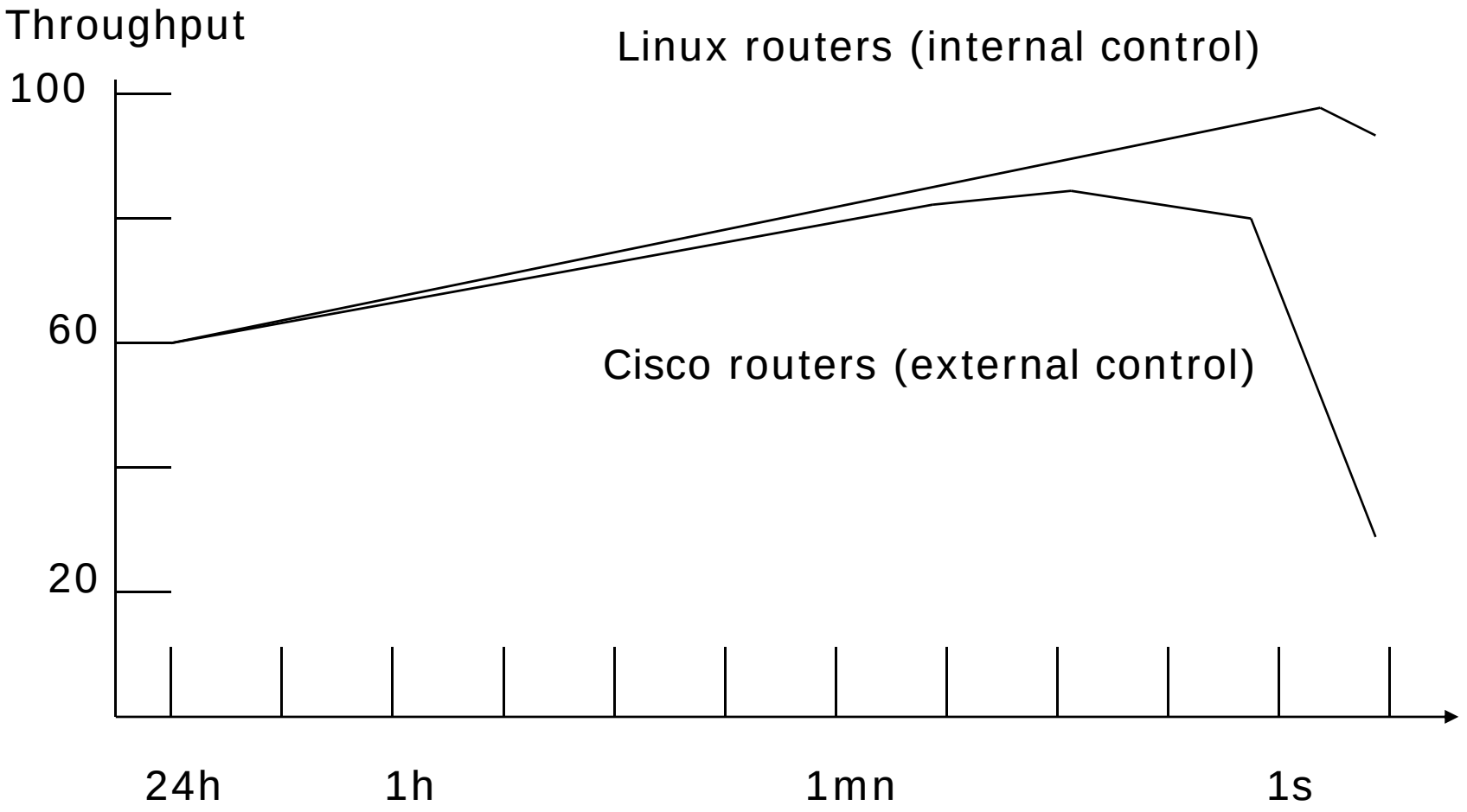
Network of 50 nodes (8 hops maximum)

DiffServ configuration

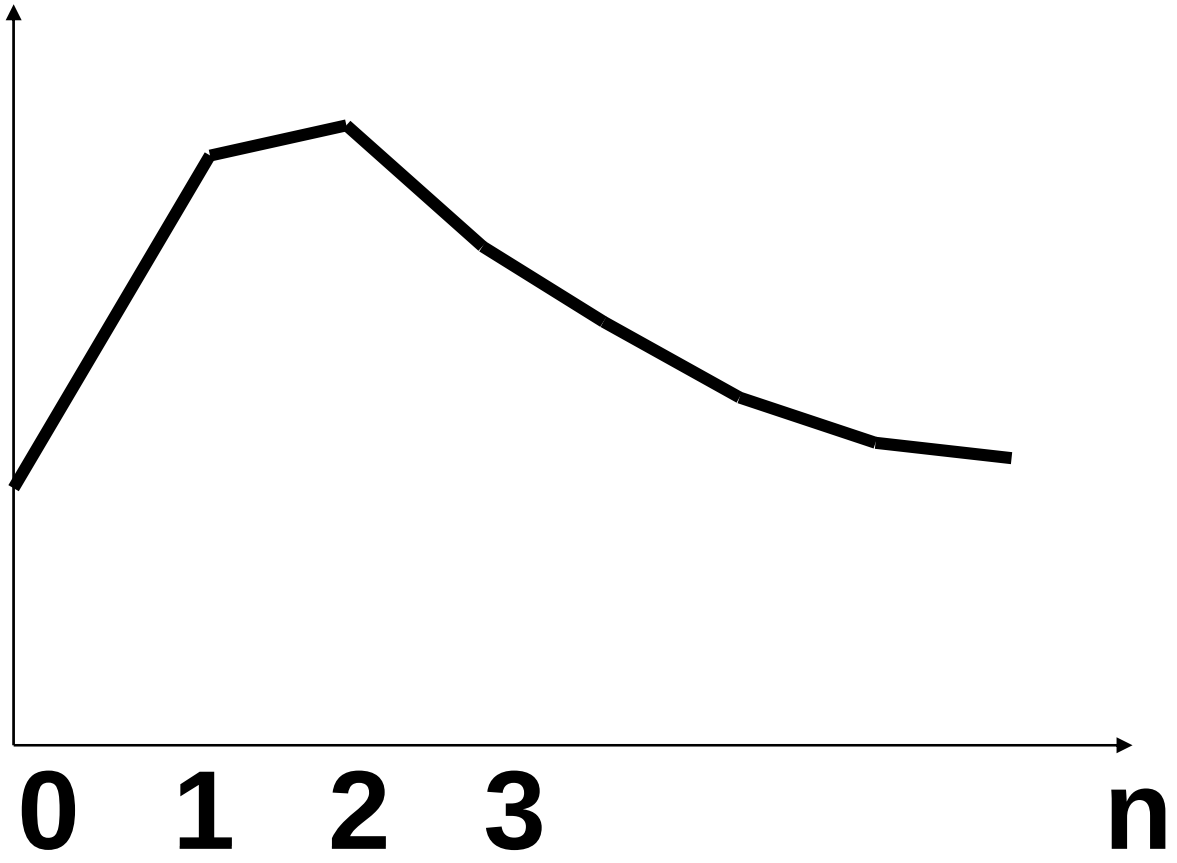
DiffServ Configuration



Performance

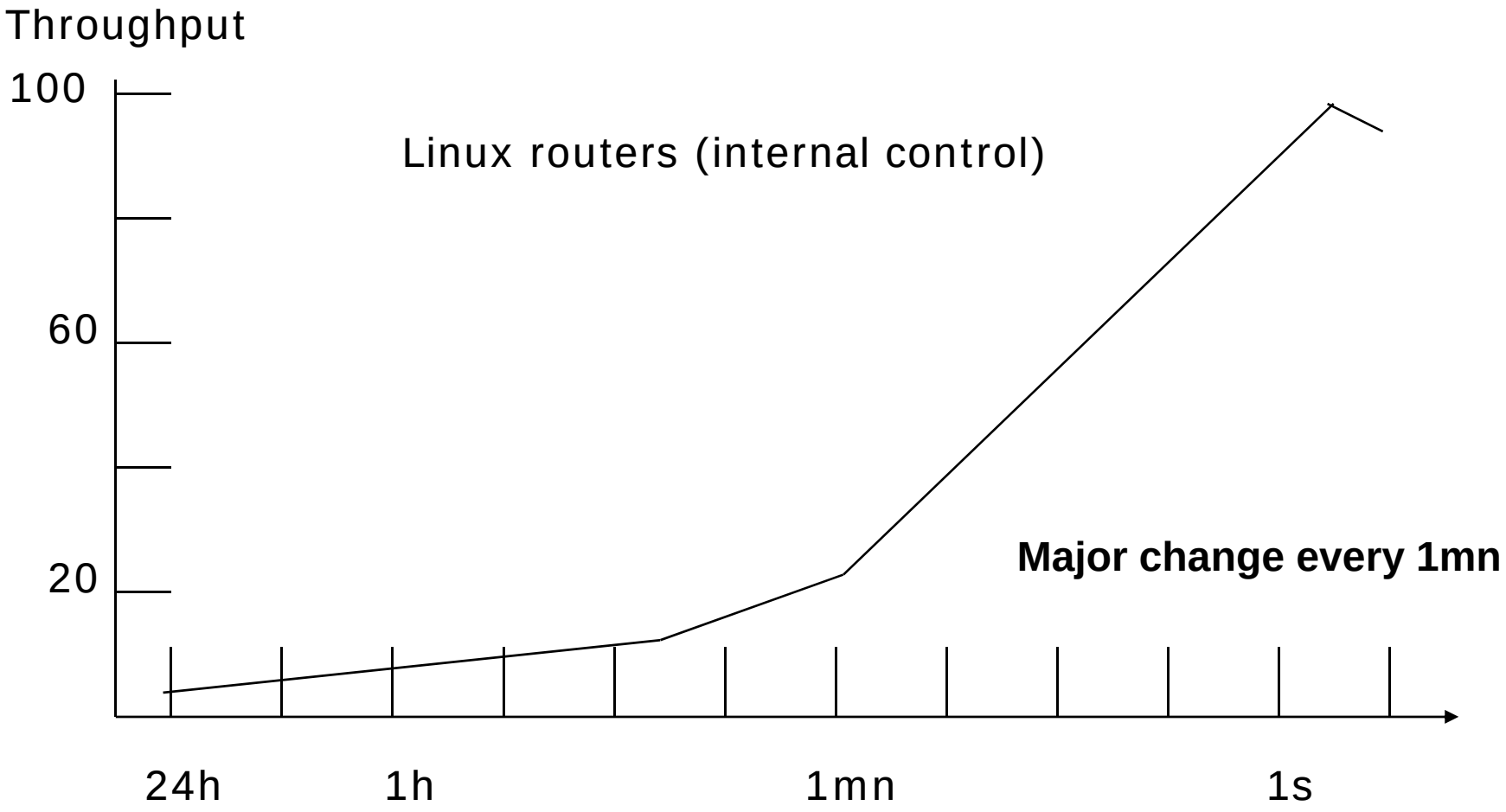


Knowledge distance



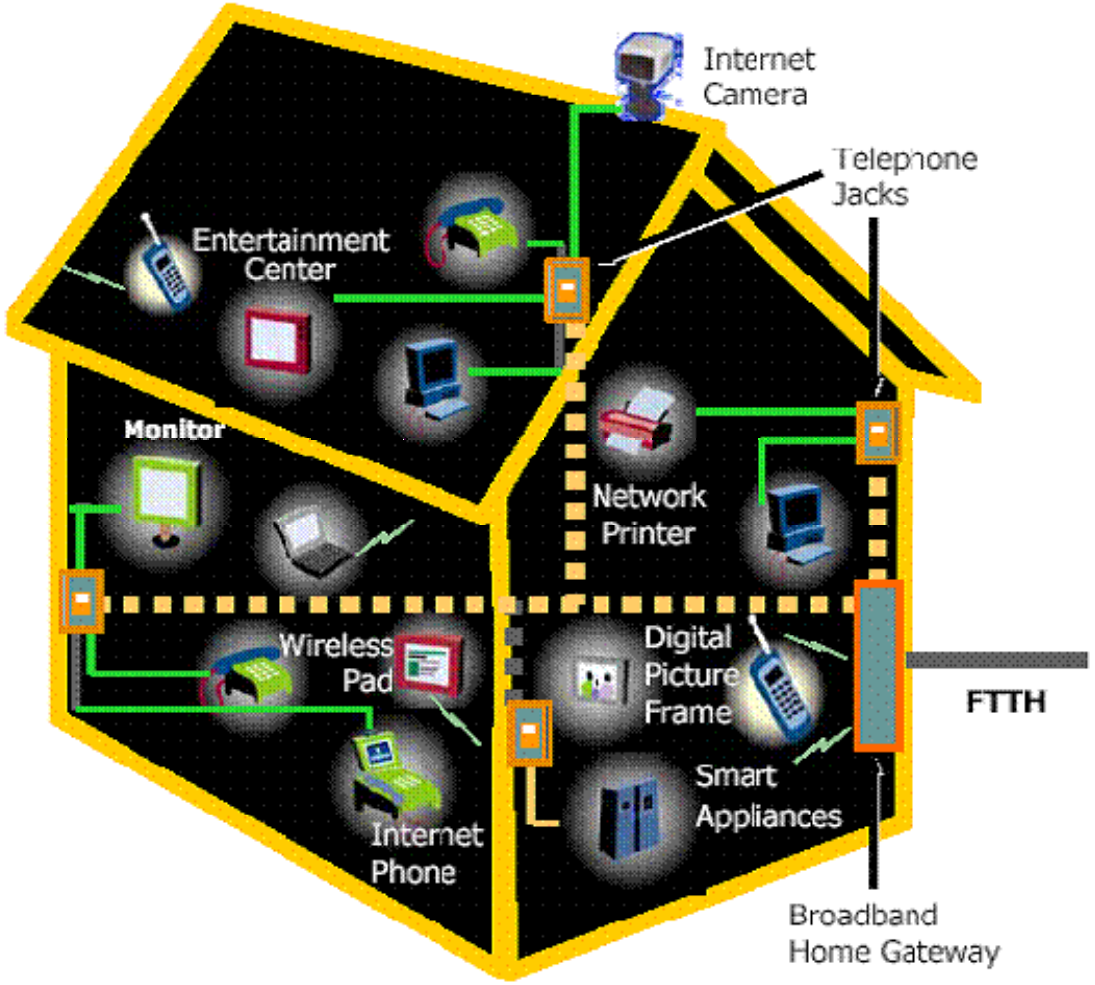
DiffServ configuration

- **DiffServ configuration in dynamic environment**

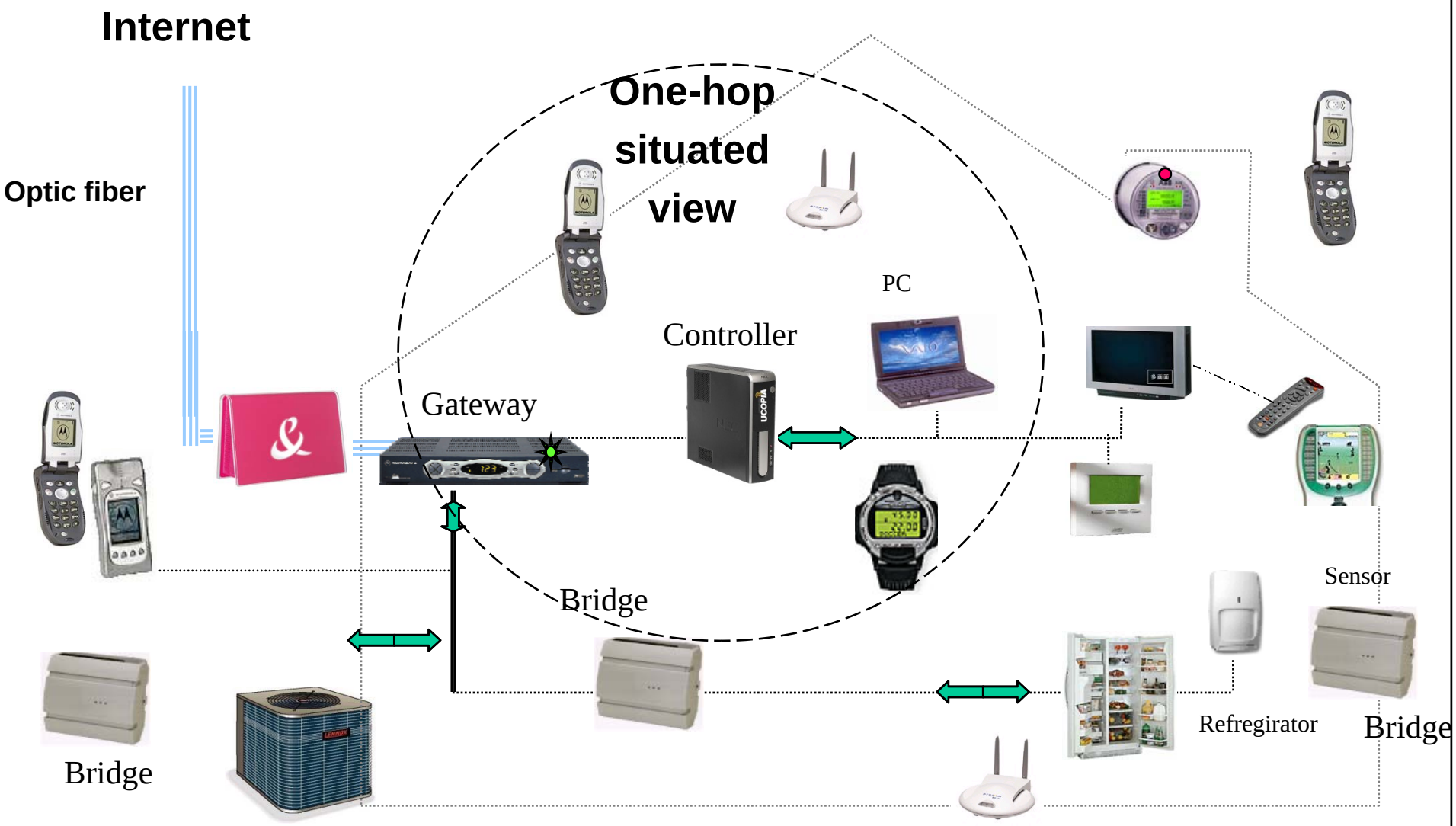


Autonomic Home Networking

Autonomic Home Networking



Home networking



Autonomic home networking

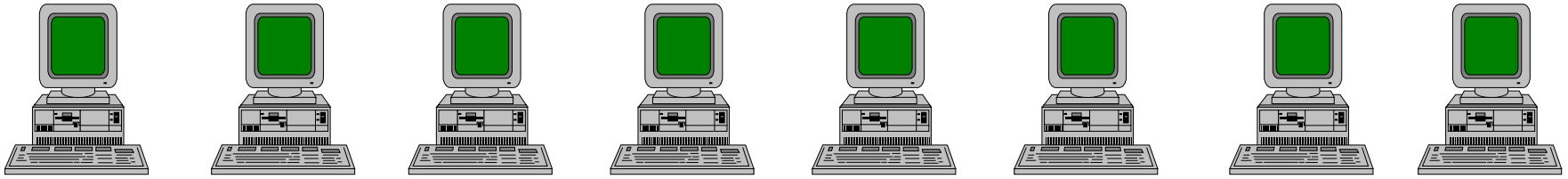
- **Develop a piloting plane distributed on each machine.**
- **Machines must support an operating system and be dependant on the home manager**
  - Internet-Box
  - Bridge
  - Access Point
  - Mobile terminal equipment
  - Set-top-box
  - PC?

Autonomic home networking

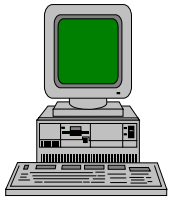
- **Networks**
  - Ethernet
  - PLC (Power Line Communication)
  - Wireless
    - UWB
    - Wi-Fi
  - Sensor networks
- **Control of the quality of service and security**
  - Situated view: one hop

Virtualization

Virtualization



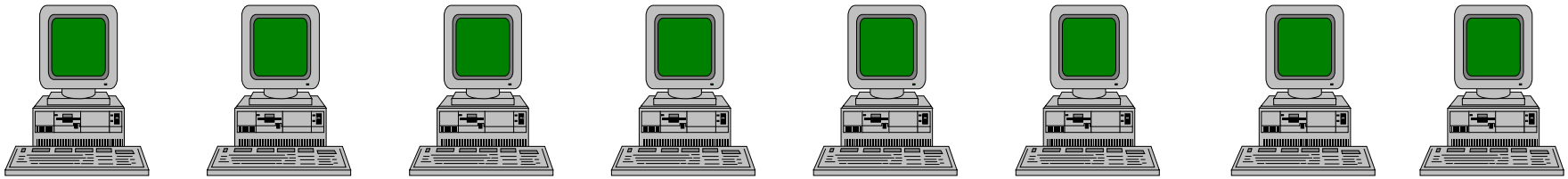
Real server



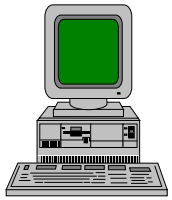
Virtual server

Clients

Virtualization



Virtual servers



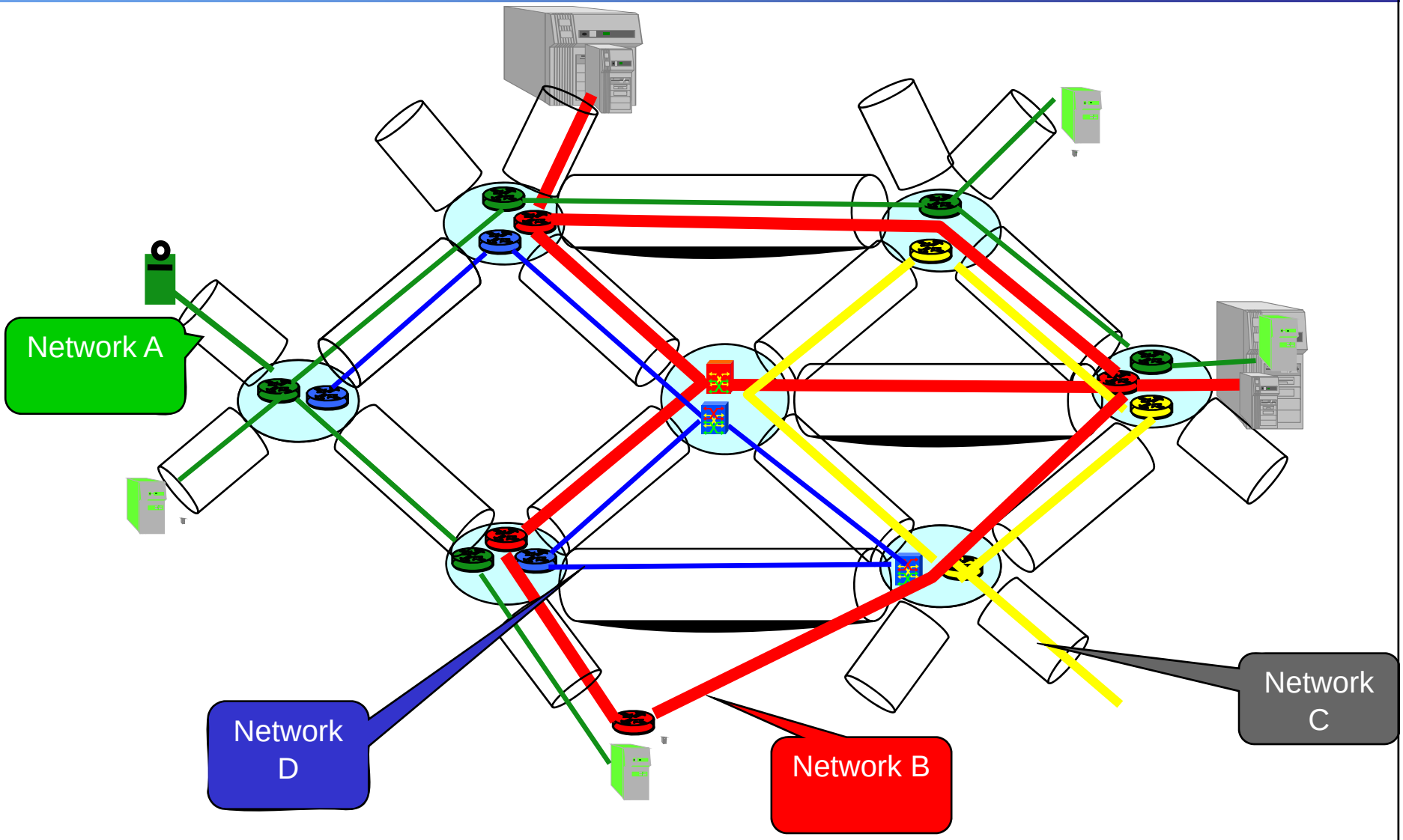
Real server

Clients

Geni

- Intel would like to propose a generic router
- Intel proposes to have a generic hardware with virtual network operating system
- A router with IOS release n and Junos and Alcatel OS and Nortel OS, etc.
- Cisco reaction is to virtualize the different releases of IOS.

Virtual router



Why virtualization?

- A better use of the resources
- Sharing of the resources for the routing schemes
- Security of the machines against attacks
- Isolation of the traffic in the virtual machines

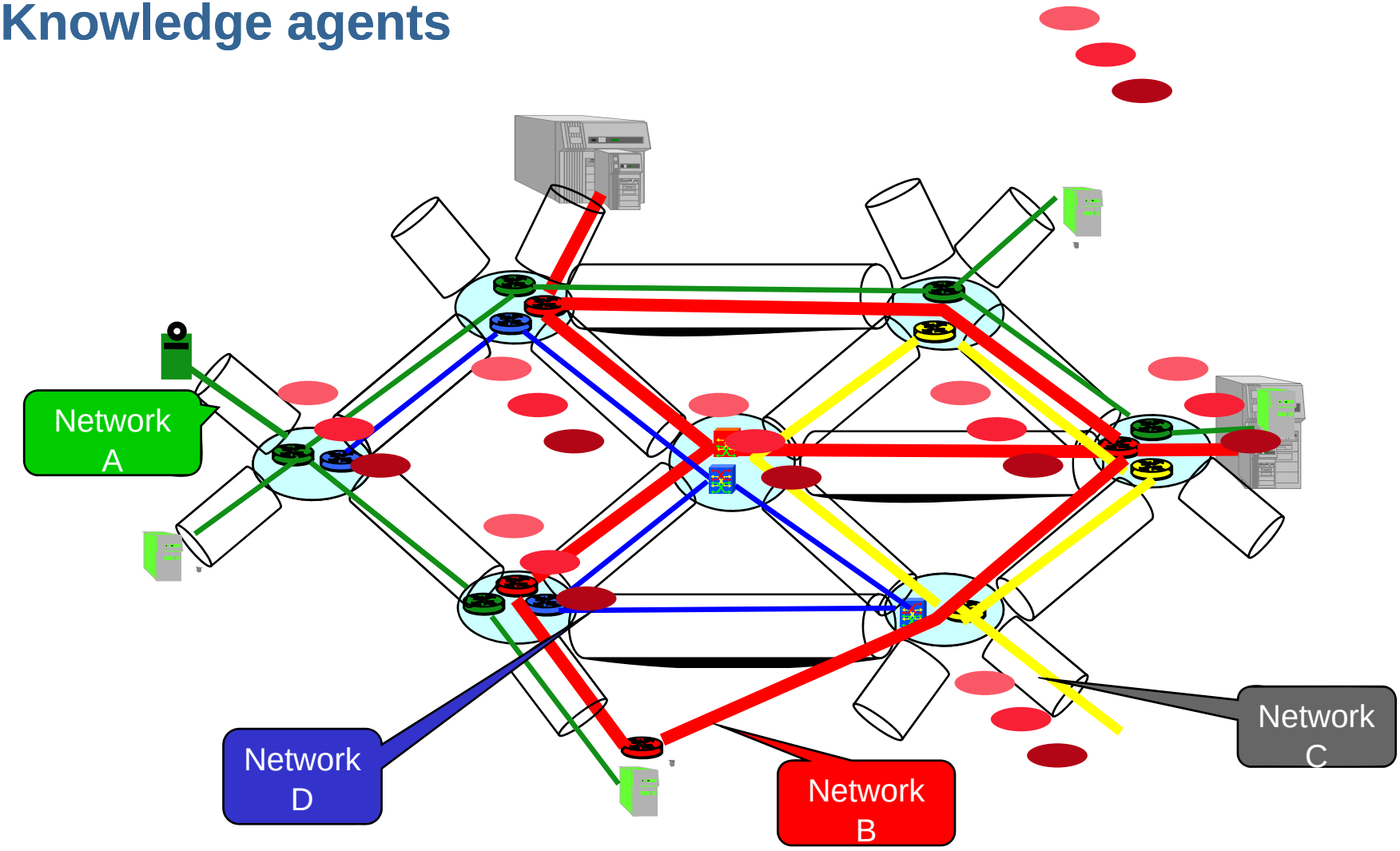
- Management and control
- Need an hypervisor
- How to move the virtual entities (router, etc.)

Virtualization

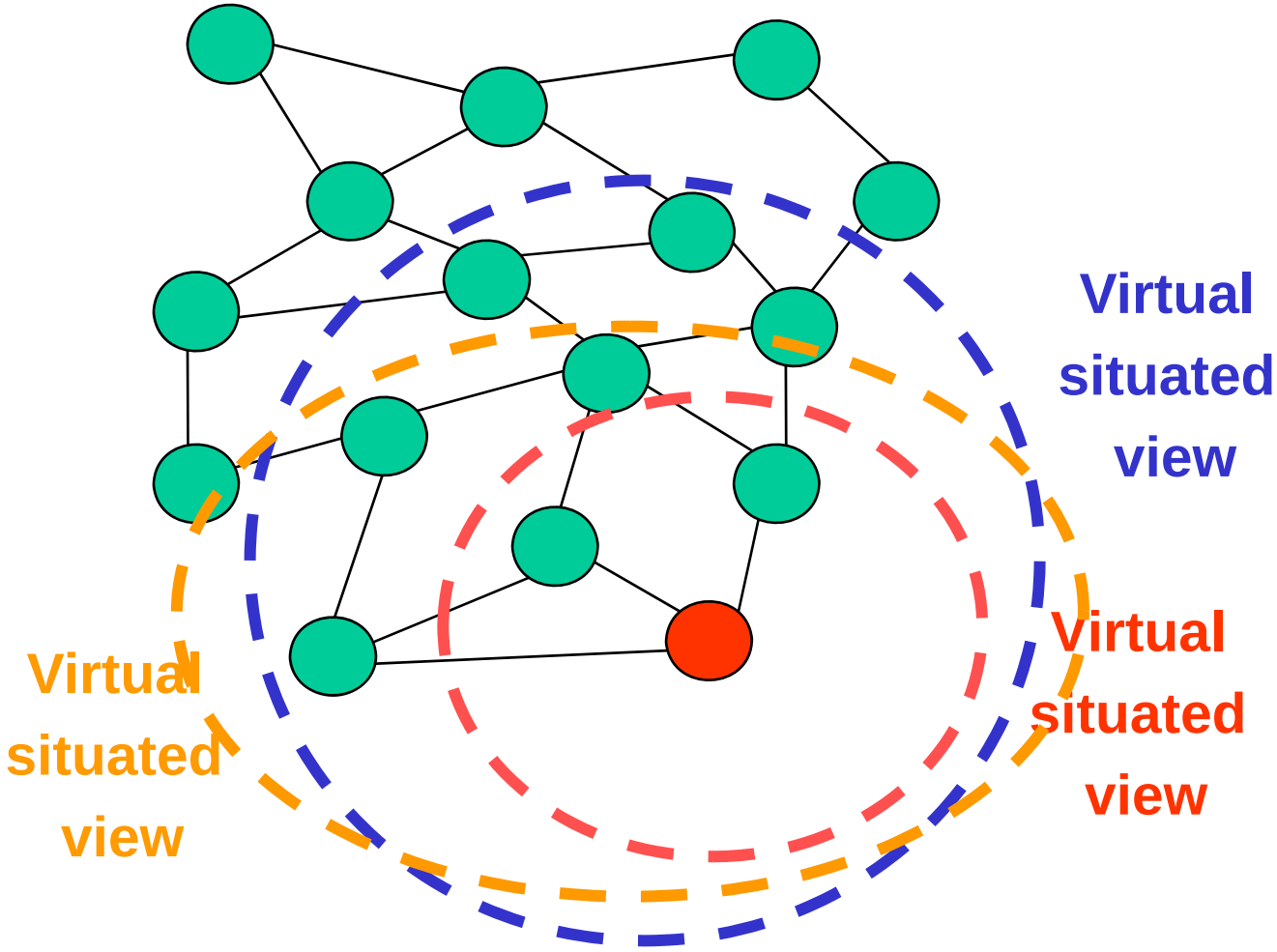
- **Virtualization of the machines**
  - Classical
- **Virtualization of the Network OS**
  - Virtualization of the planes and the protocols
    - Knowledge plane: virtual knowledge agents
    - Piloting plane: virtual piloting agents (software)
    - Control plane: virtual algorithms
    - Data plane: virtual protocols
- **Virtualization of the services**
  - Classical (data center, centrex, etc.)

Virtualization of the Knowledge Plane

- **Knowledge agents**

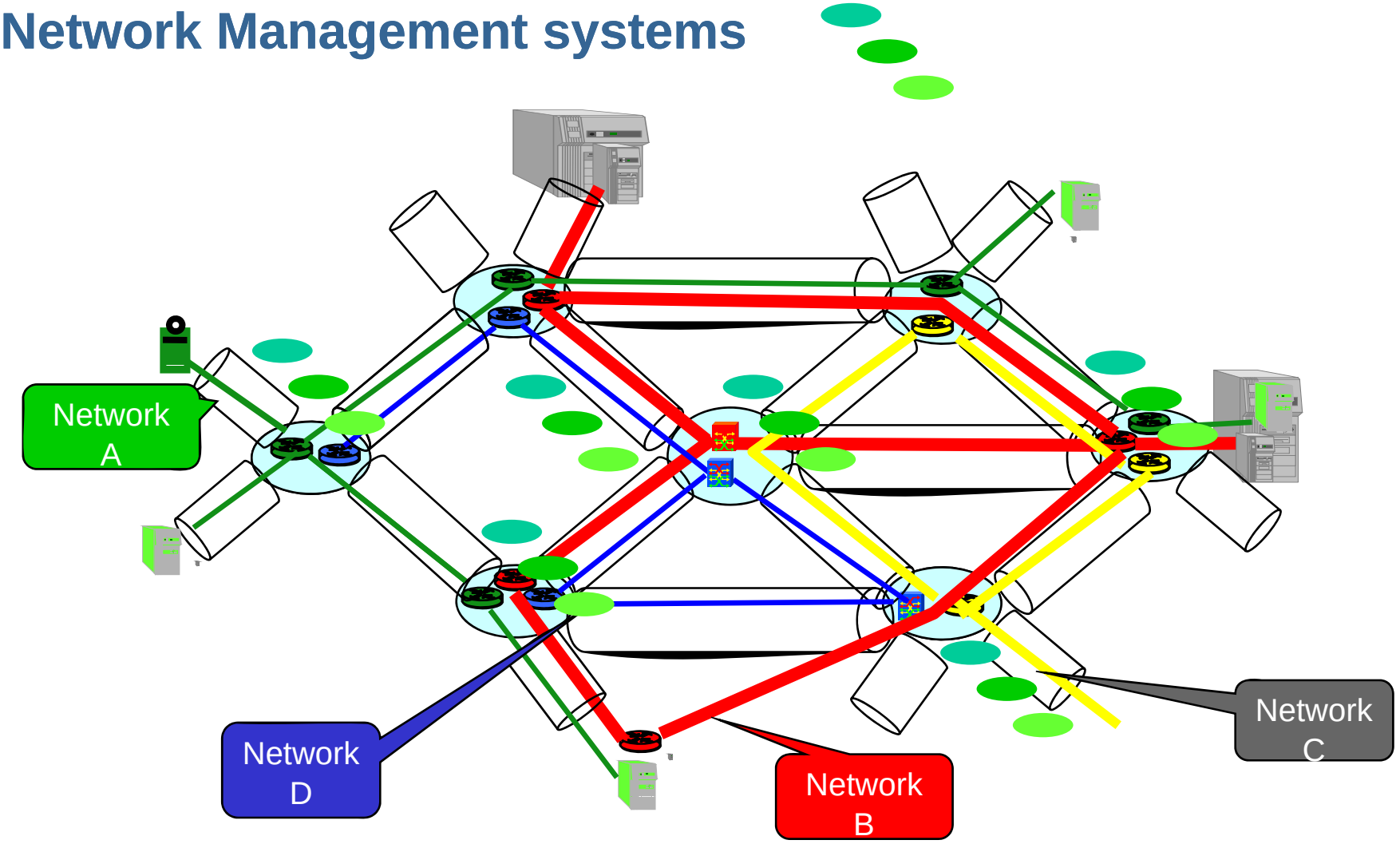


Virtualization of the Knowledge Plane

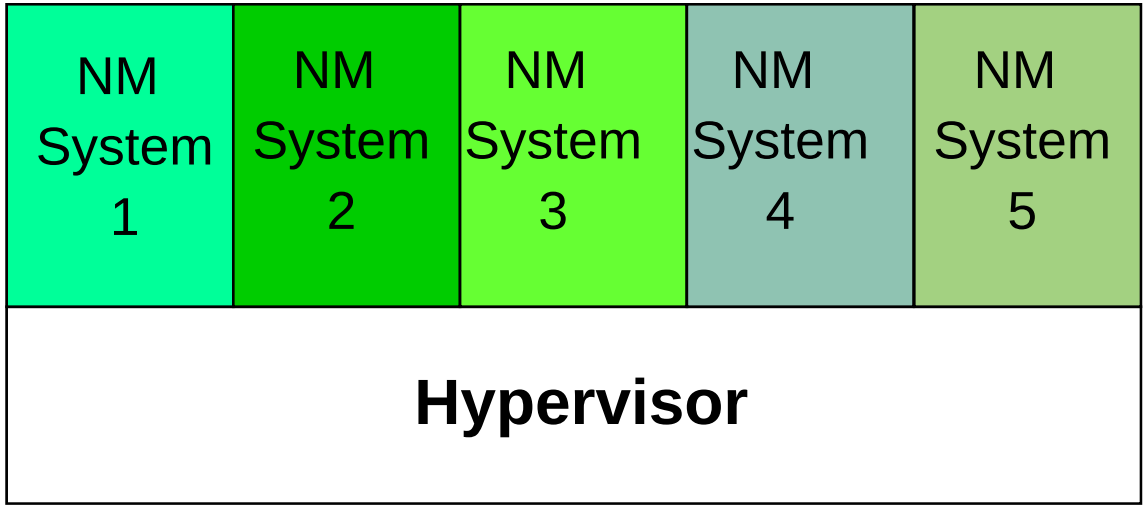


Virtualization of the Management Plane

- **Network Management systems**

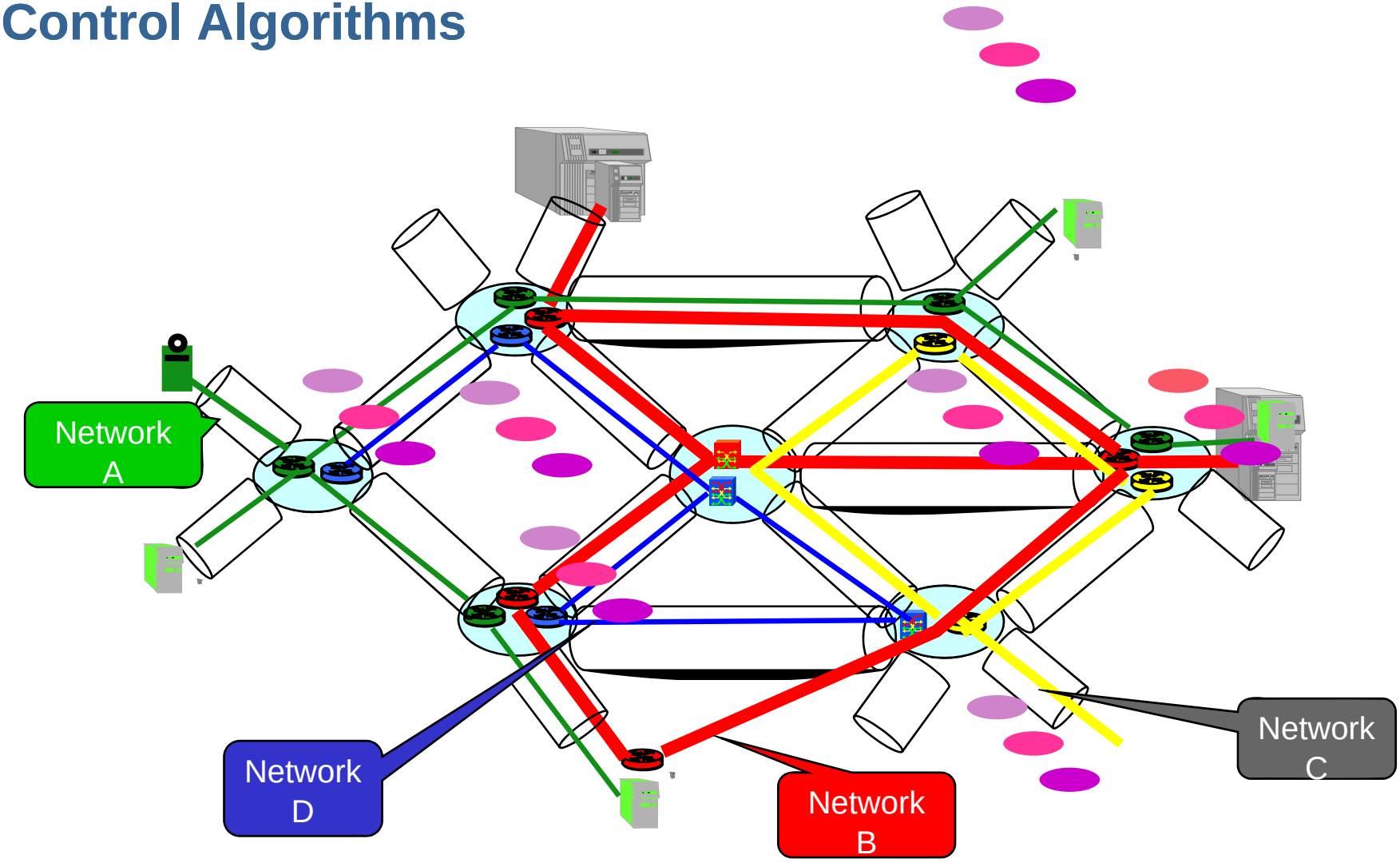


Virtualization of the Management Plane

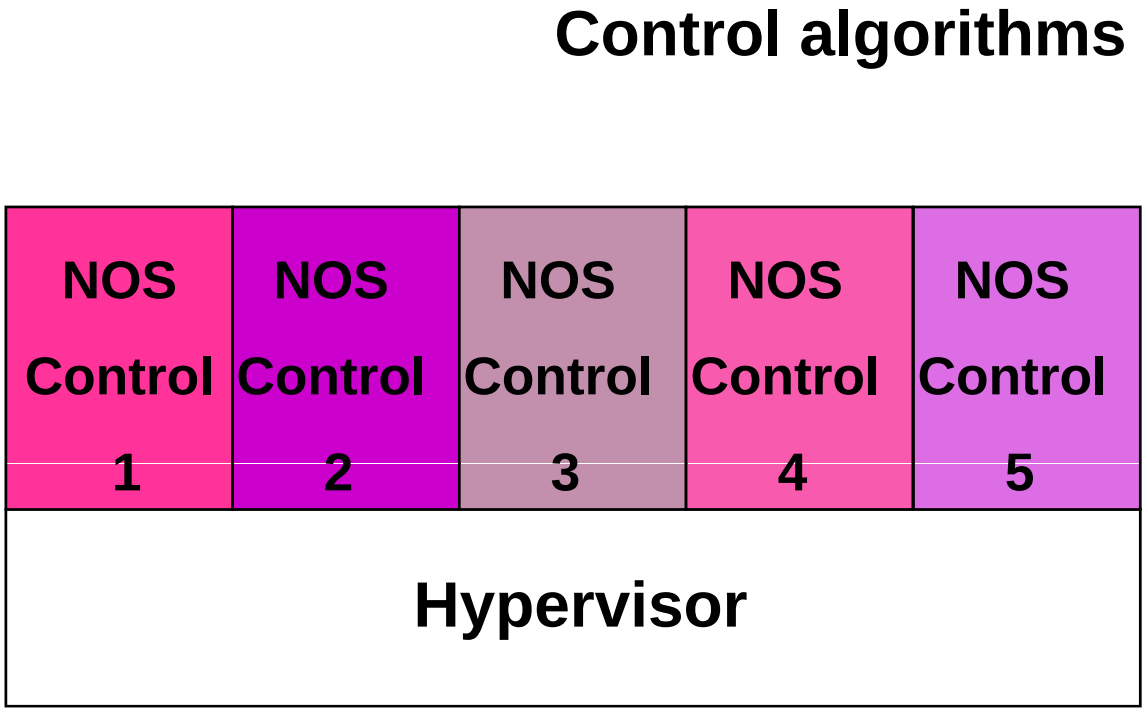


Virtualization of the control plane

- **Control Algorithms**

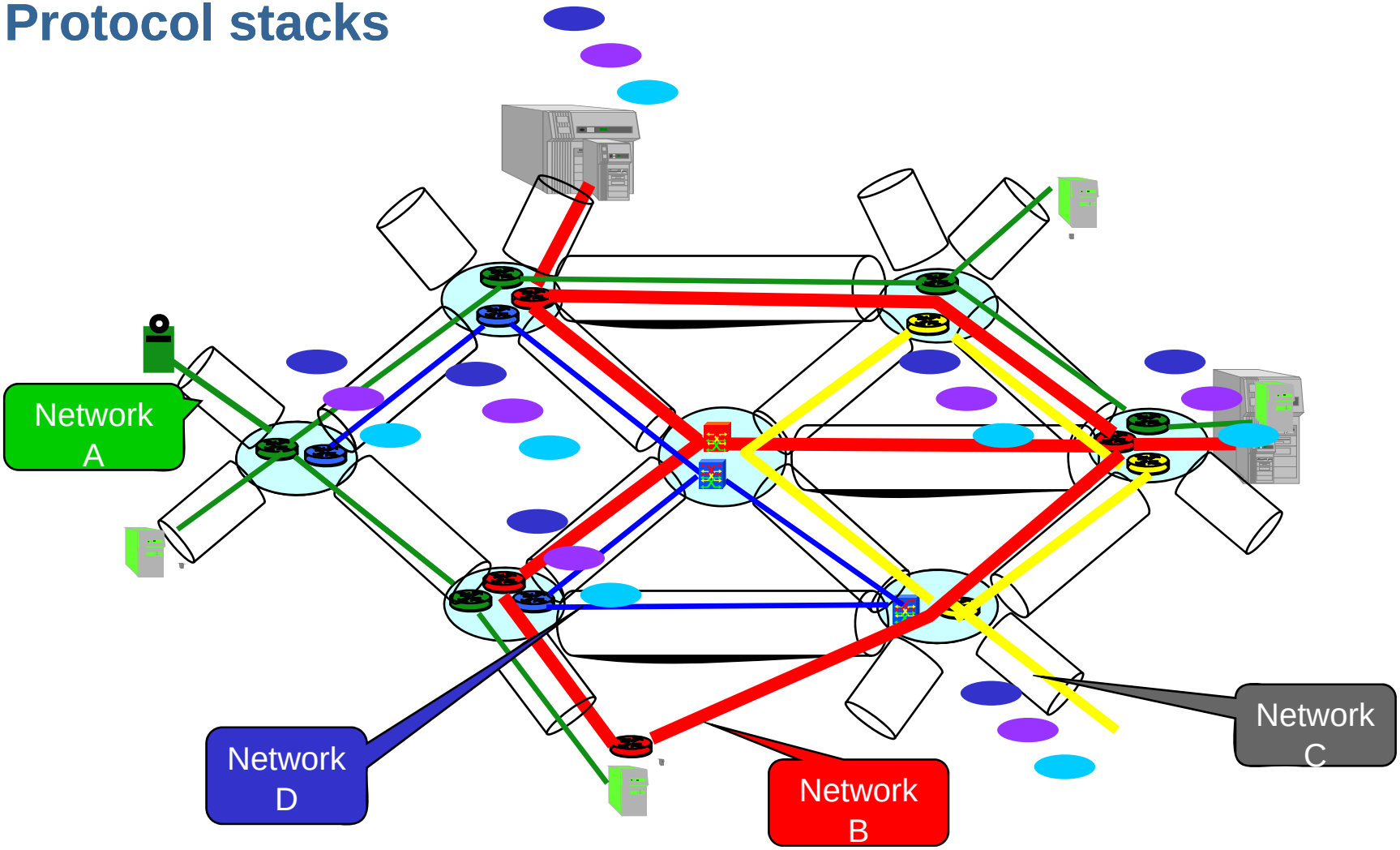


Virtualization of the Control Plane

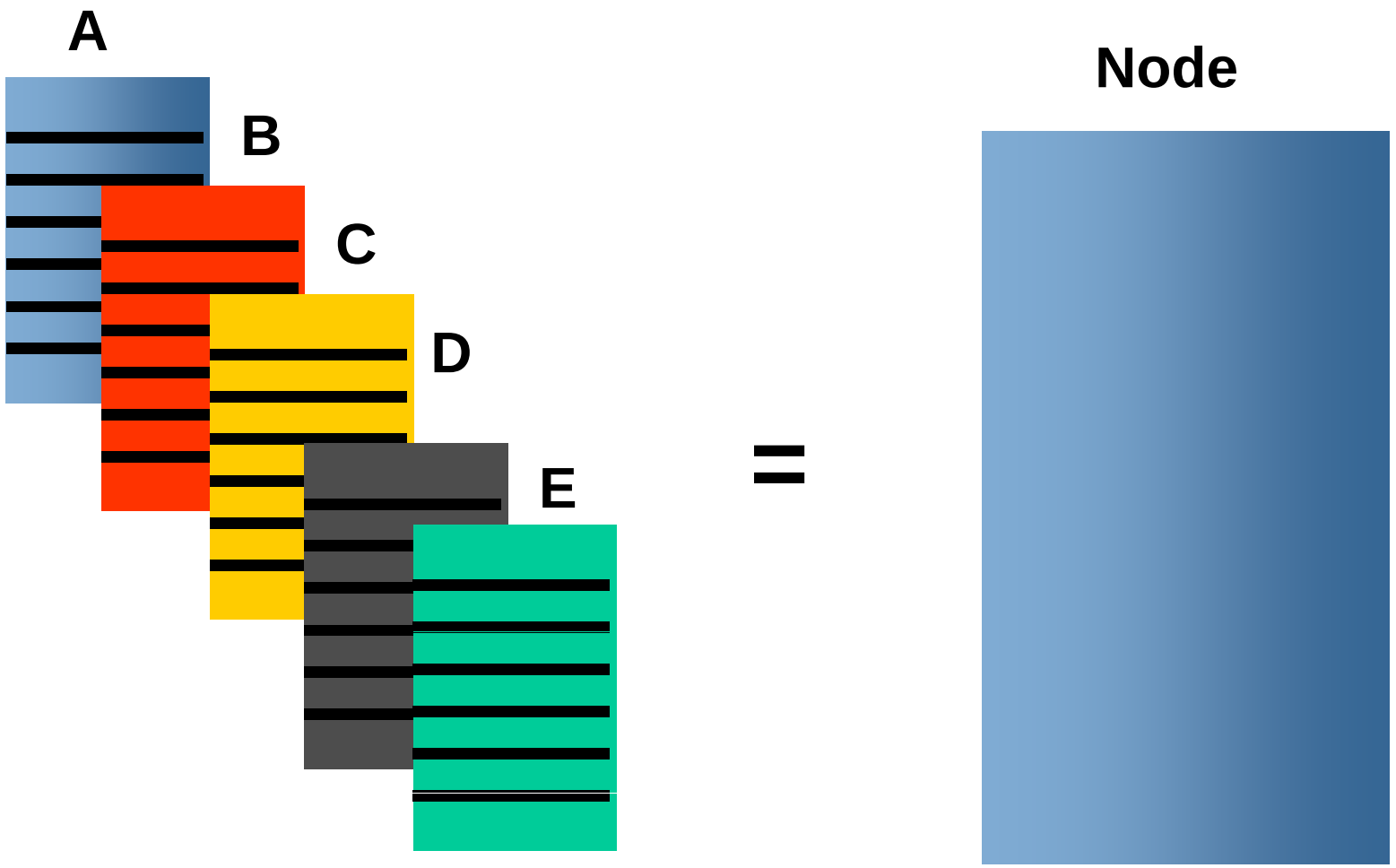


Virtualization of the Data Plane

- **Protocol stacks**

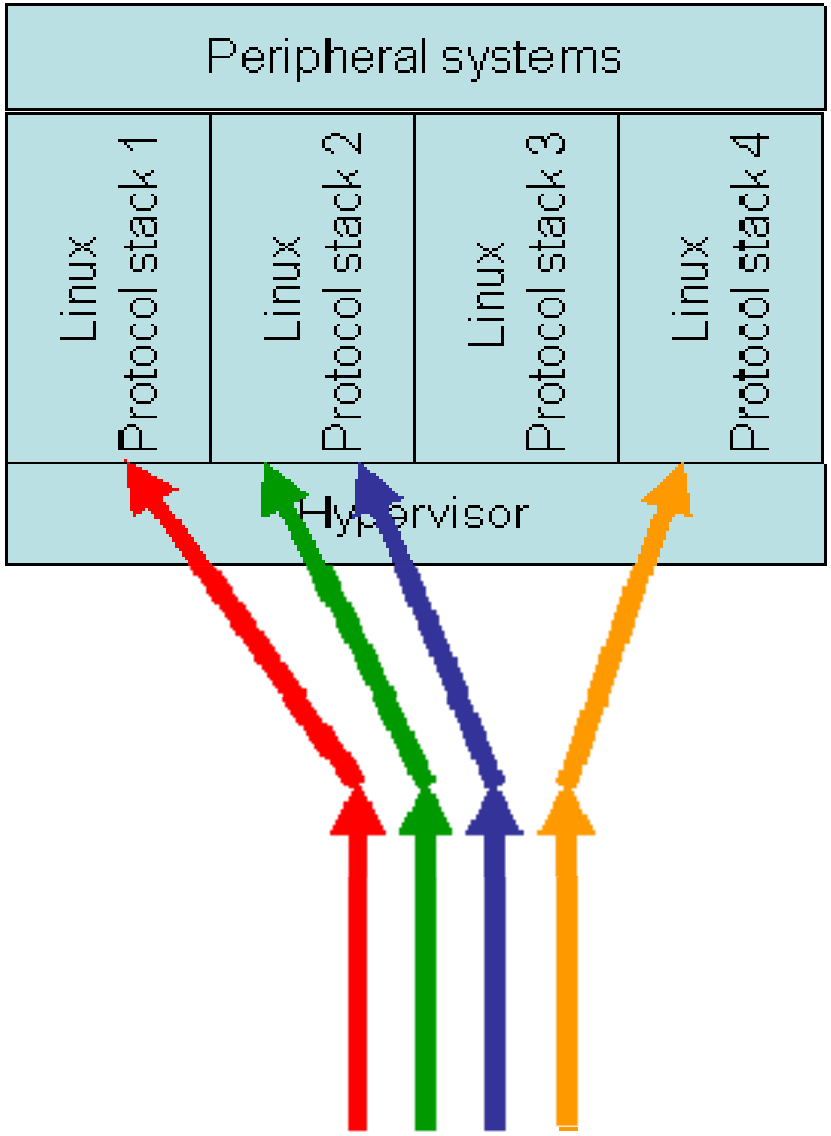


Virtualization of the Data Plane

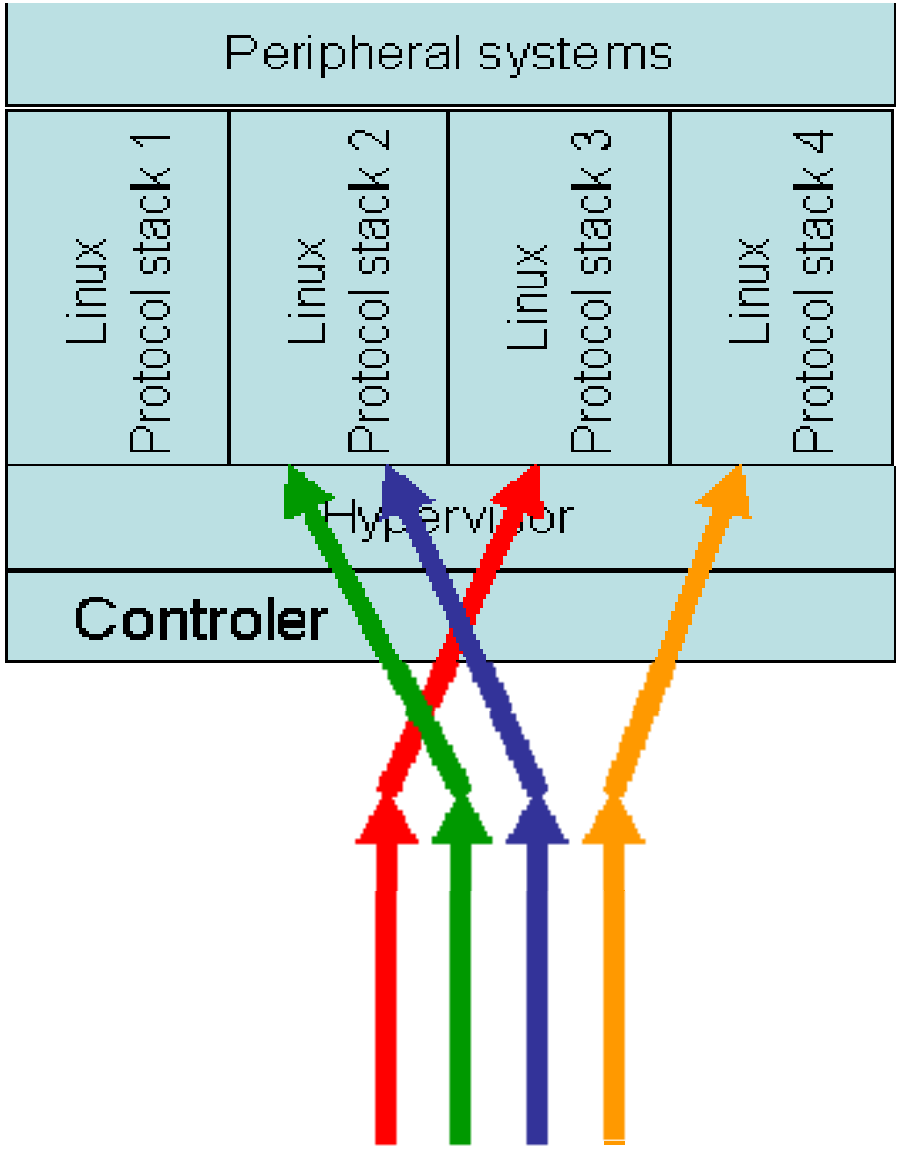


A = IP stack is mandatory in the core network

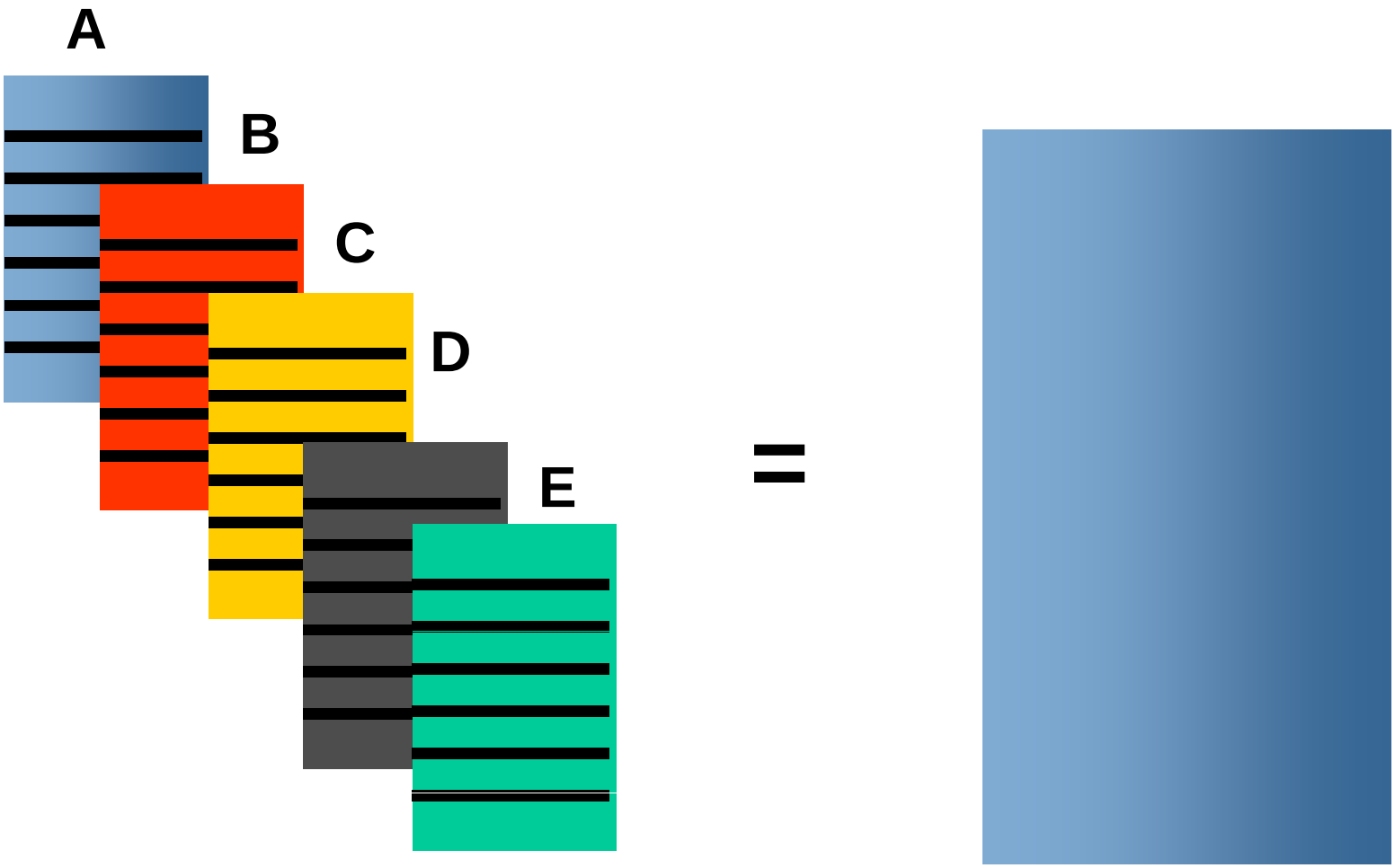
Virtualization of the Data Plane



Virtualization of the Data Plane



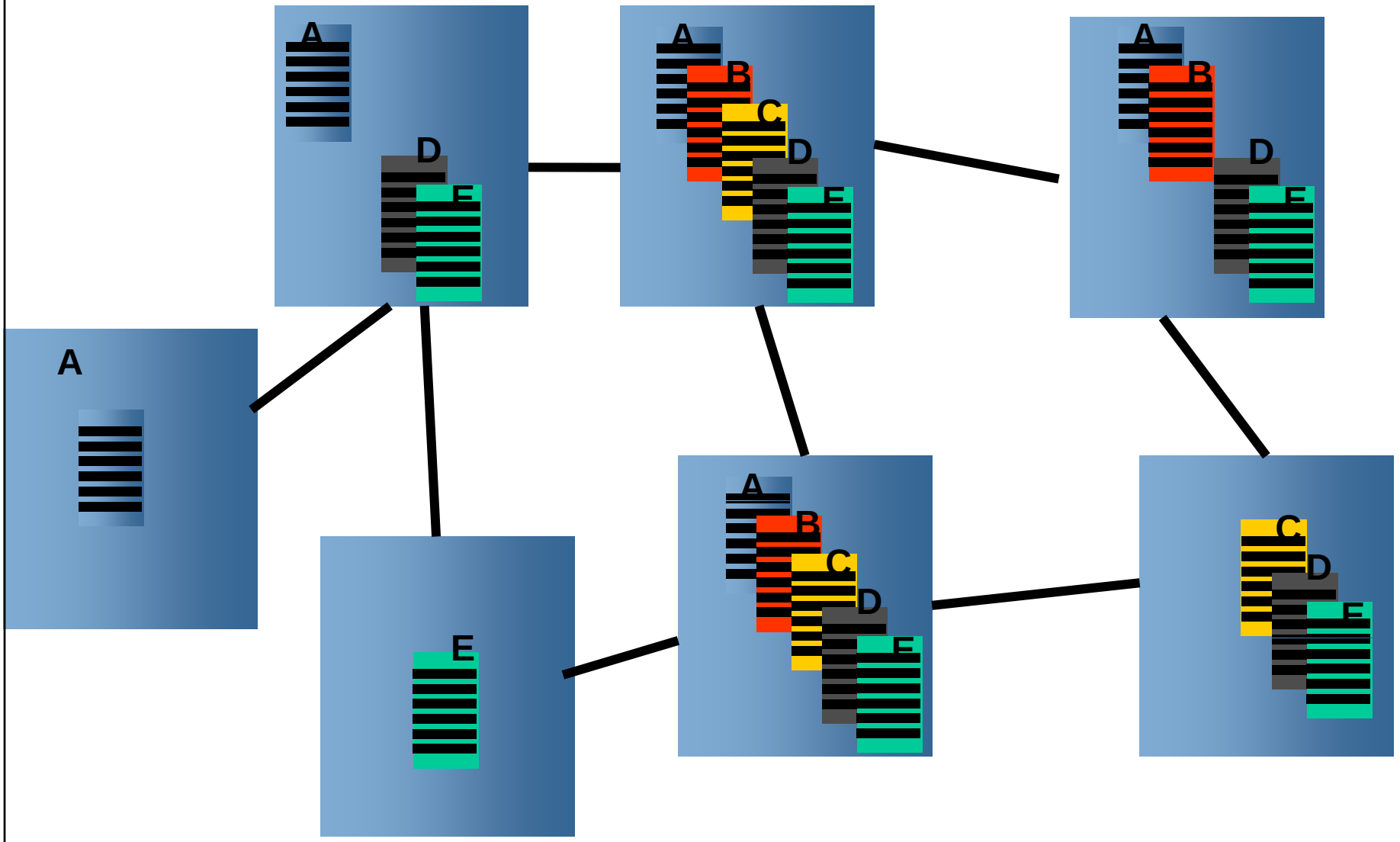
Virtualization of the protocols



A = IP stack is mandatory in the core network

within the virtual protocol

Virtualization of protocol stacks

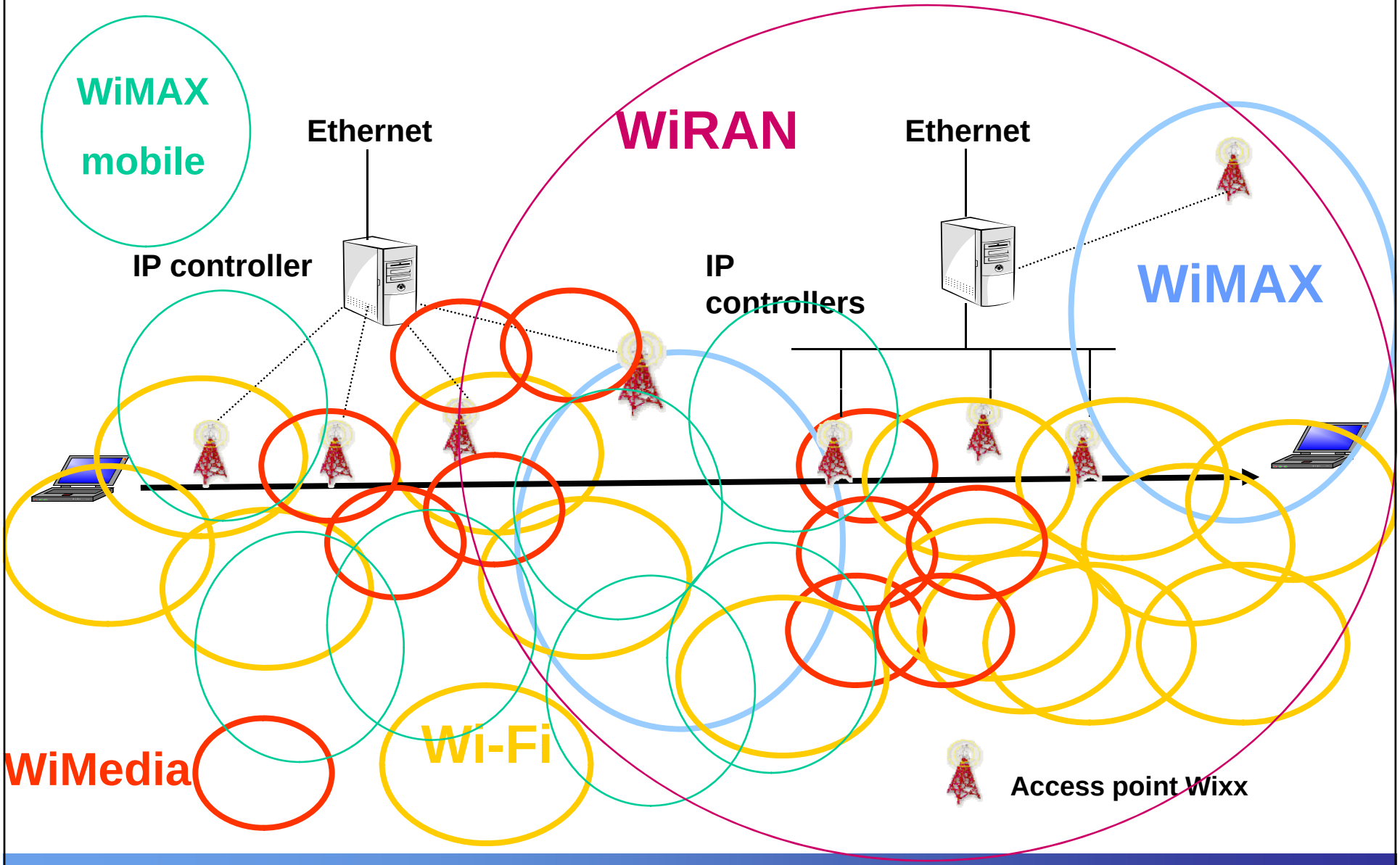


Virtualization

- An old paradigm
- A new networking paradigm

Piloting the Wireless Internet

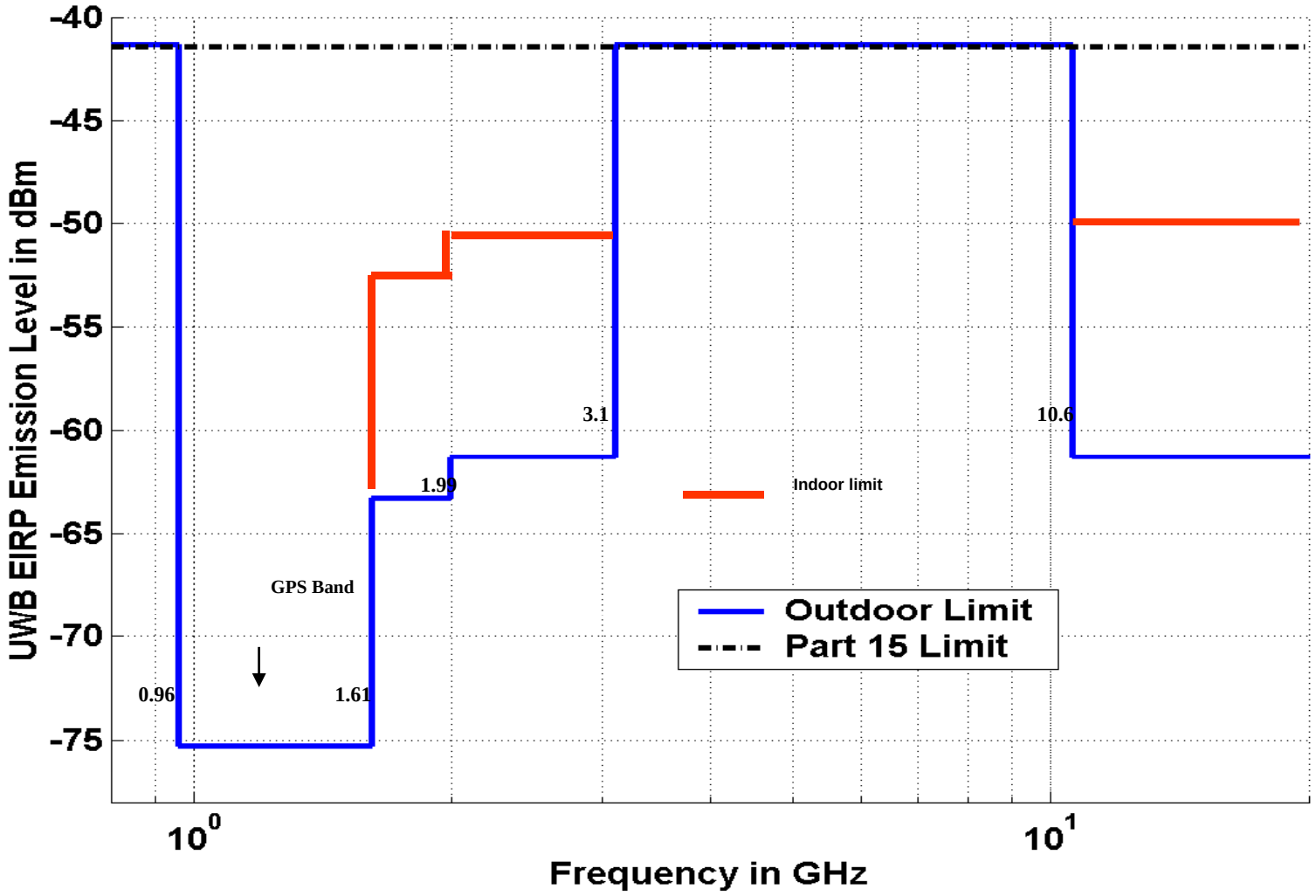
Wireless Internet



Ultra Wide Band

UWB

UWB

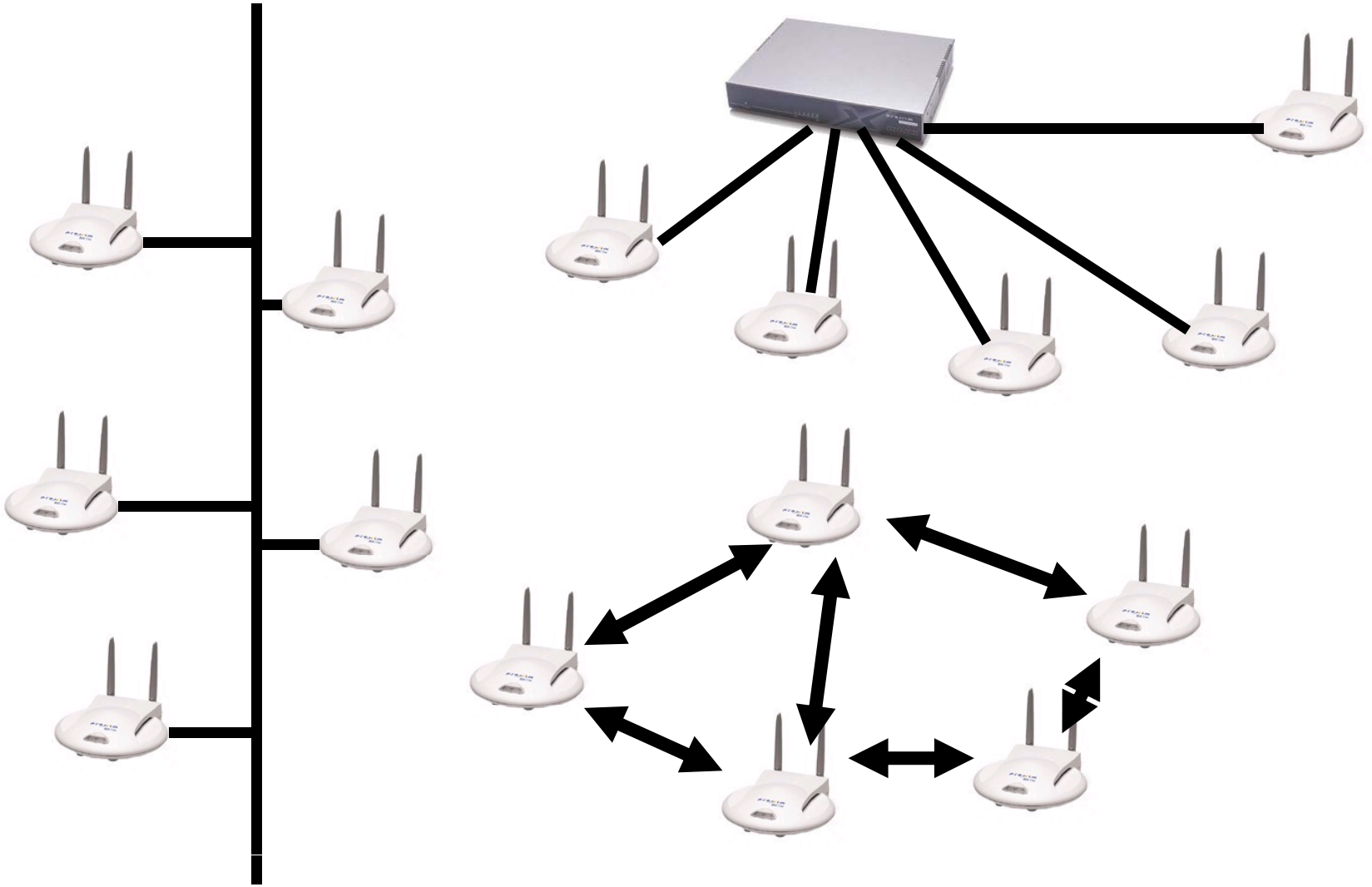

-40
-45
-50
-55
-60
-65
-70
-75
UWB EIRP Emission Level in dBm
10^0
10^1
Frequency in GHz
0.96
1.61
1.99
3.1
10.6
GPS Band
Indoor limit
Outdoor Limit
Part 15 Limit

Wi-Fi

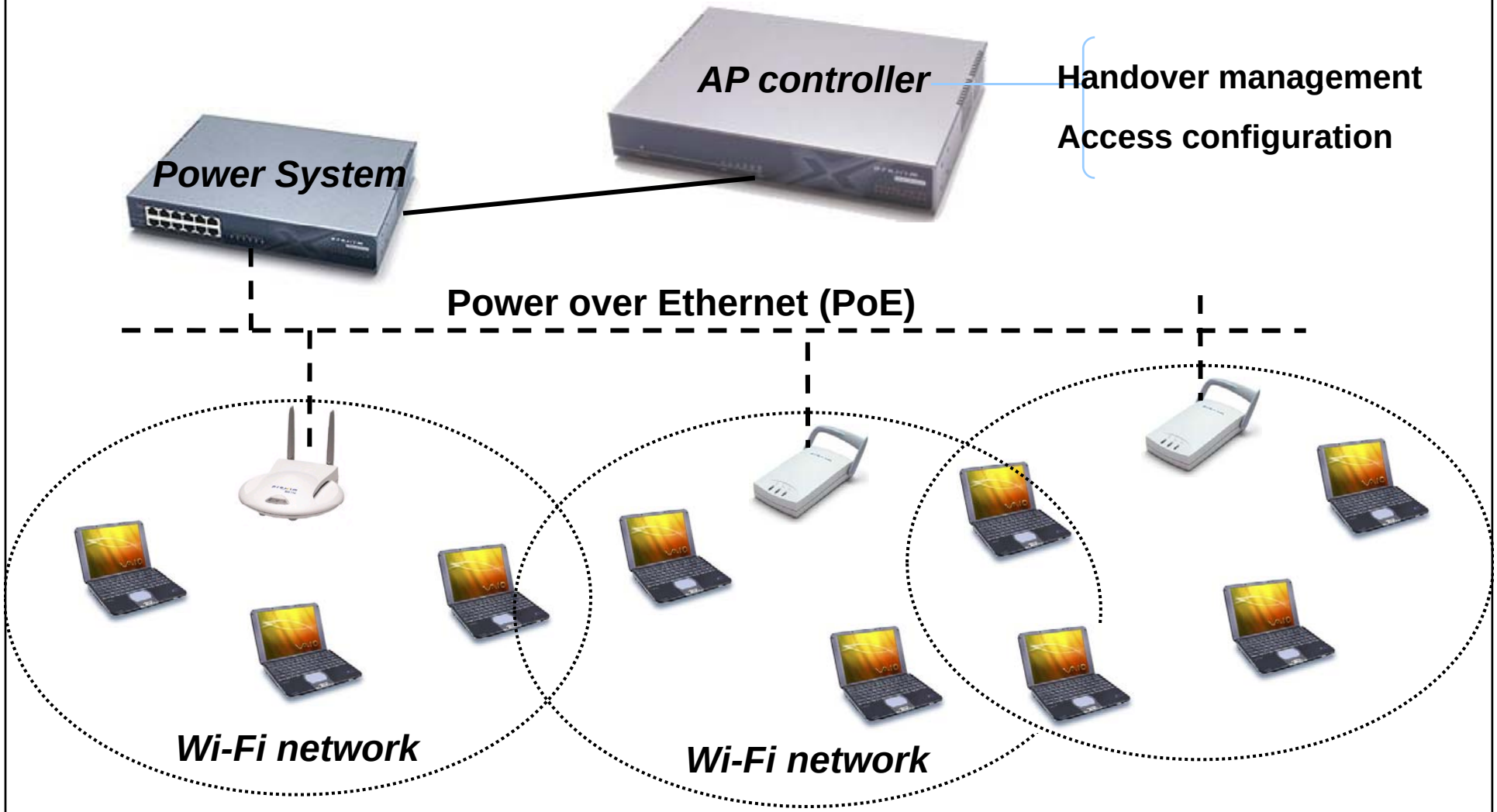
CAPWAP

- **Control And Provisionning of Wireless Access Point**
- **Three types of Wi-Fi architecture**
  - Autonomous WLAN Architecture
  - Centralized WLAN Architecture
  - Distributed WLAN Architecture

Wi-Fi

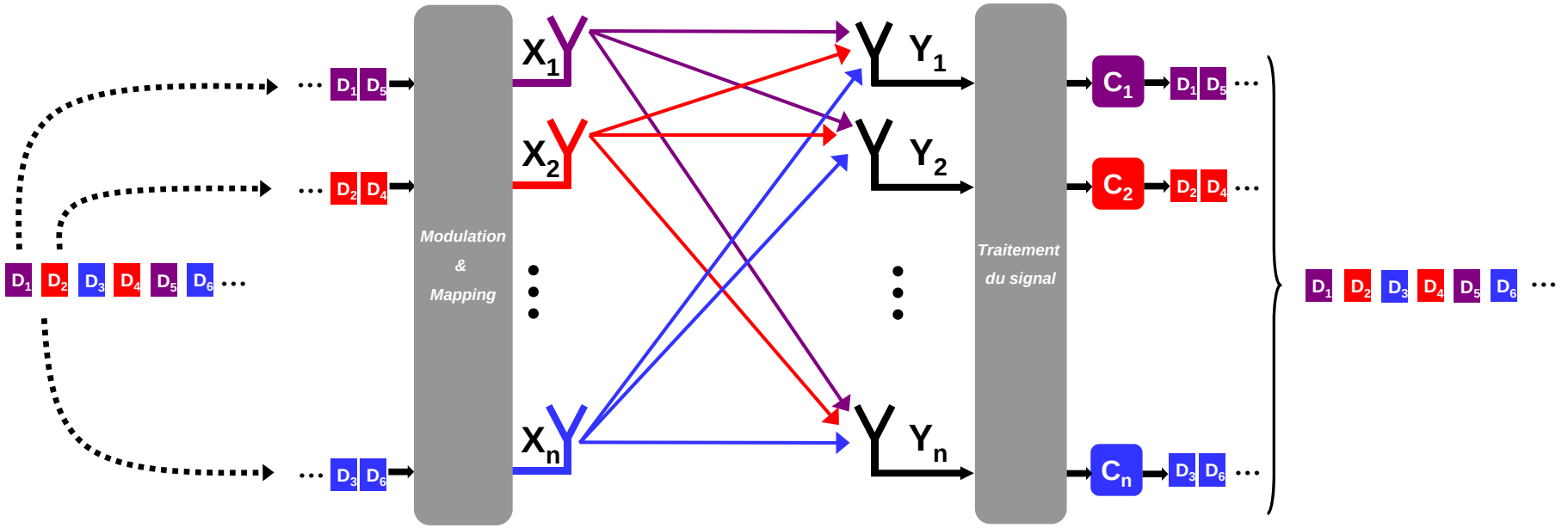


Wi-Fi networks

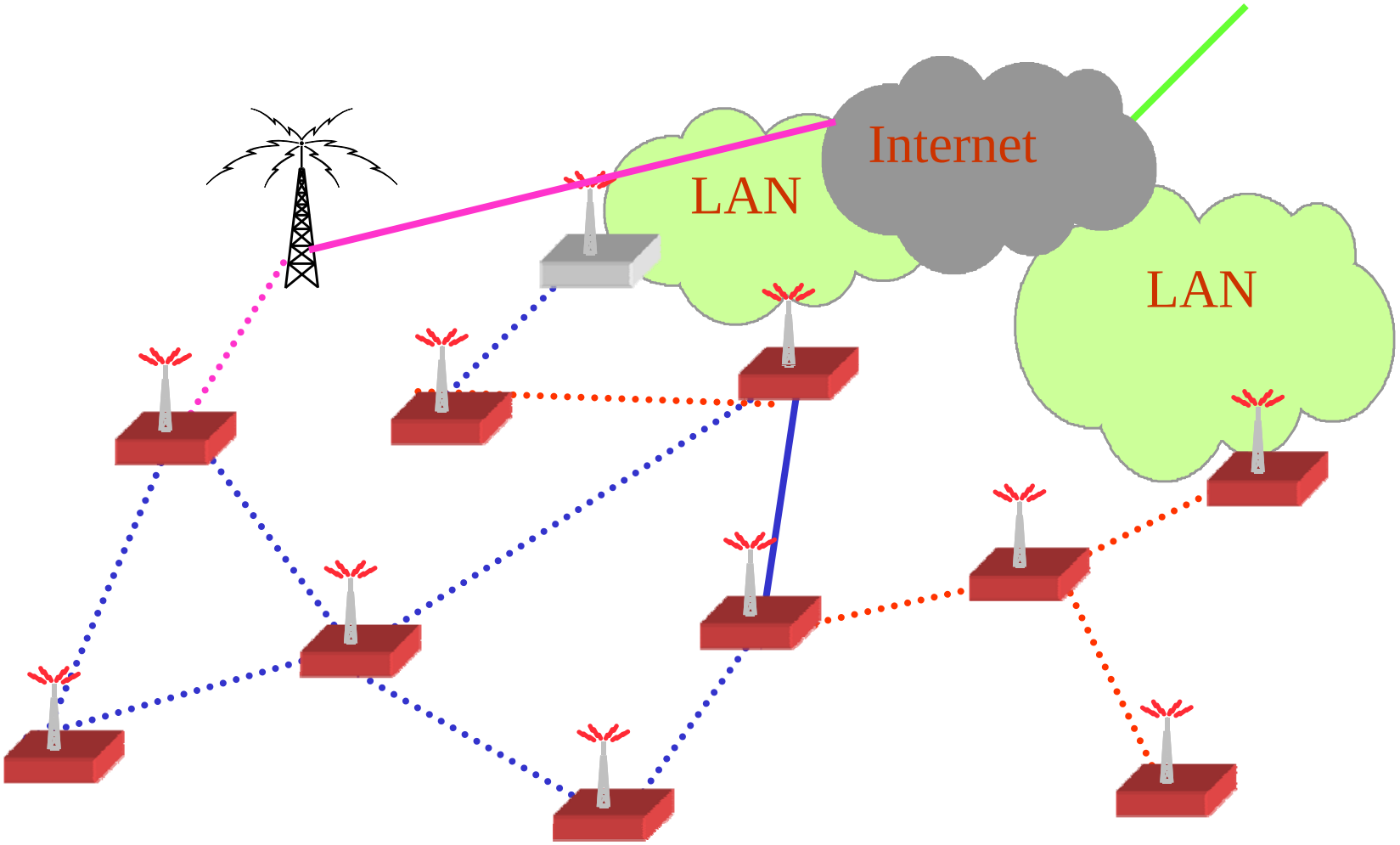


MIMO - Multiplexing (TrueMIMO™)

- Transmission speed = f($Nb_{antenne}$)
- Diversity

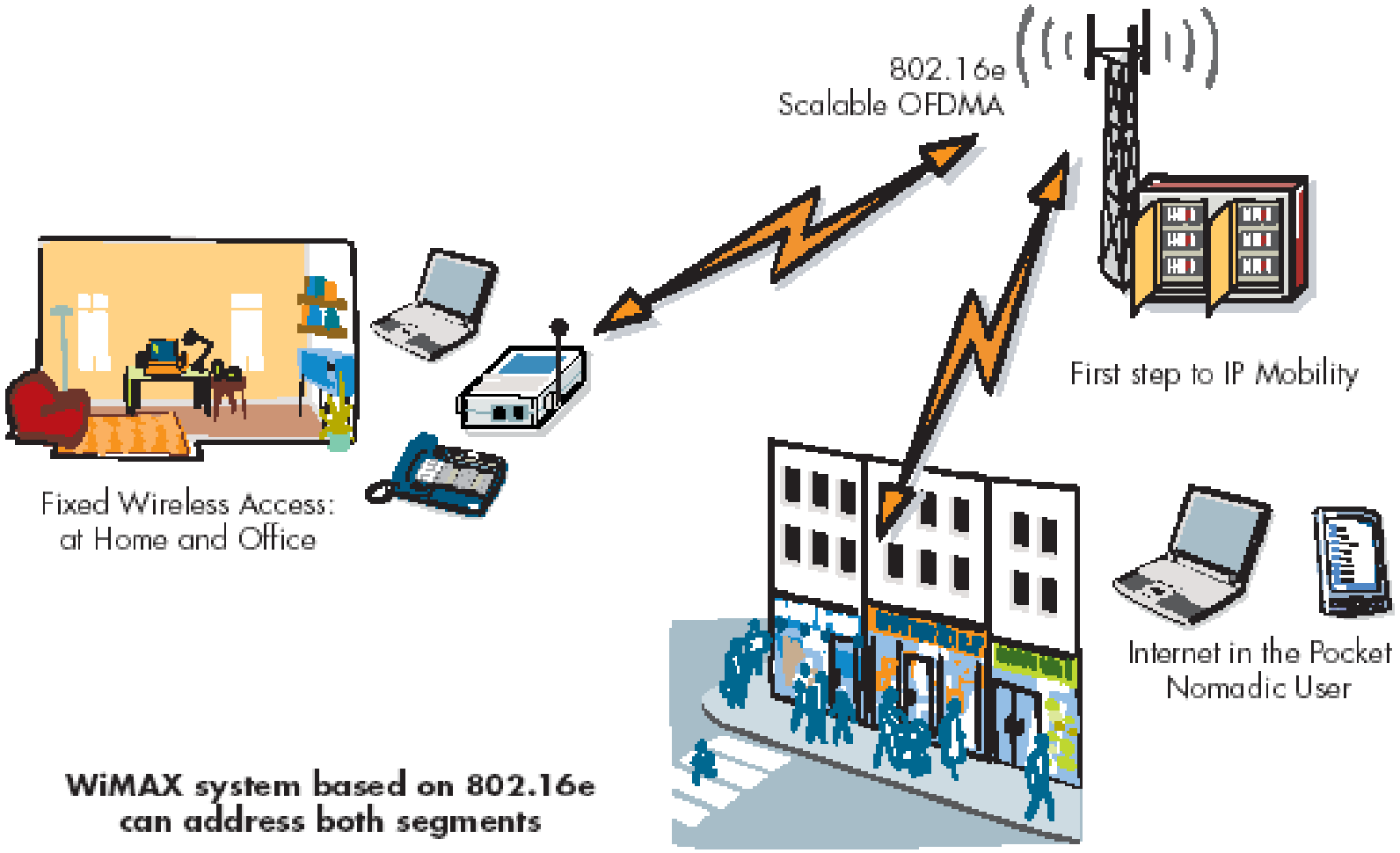


IEEE 802.11s Mesh networks



IEEE 802.16 - WiMAX

WiMAX



WiMAX system based on 802.16e can address both segments

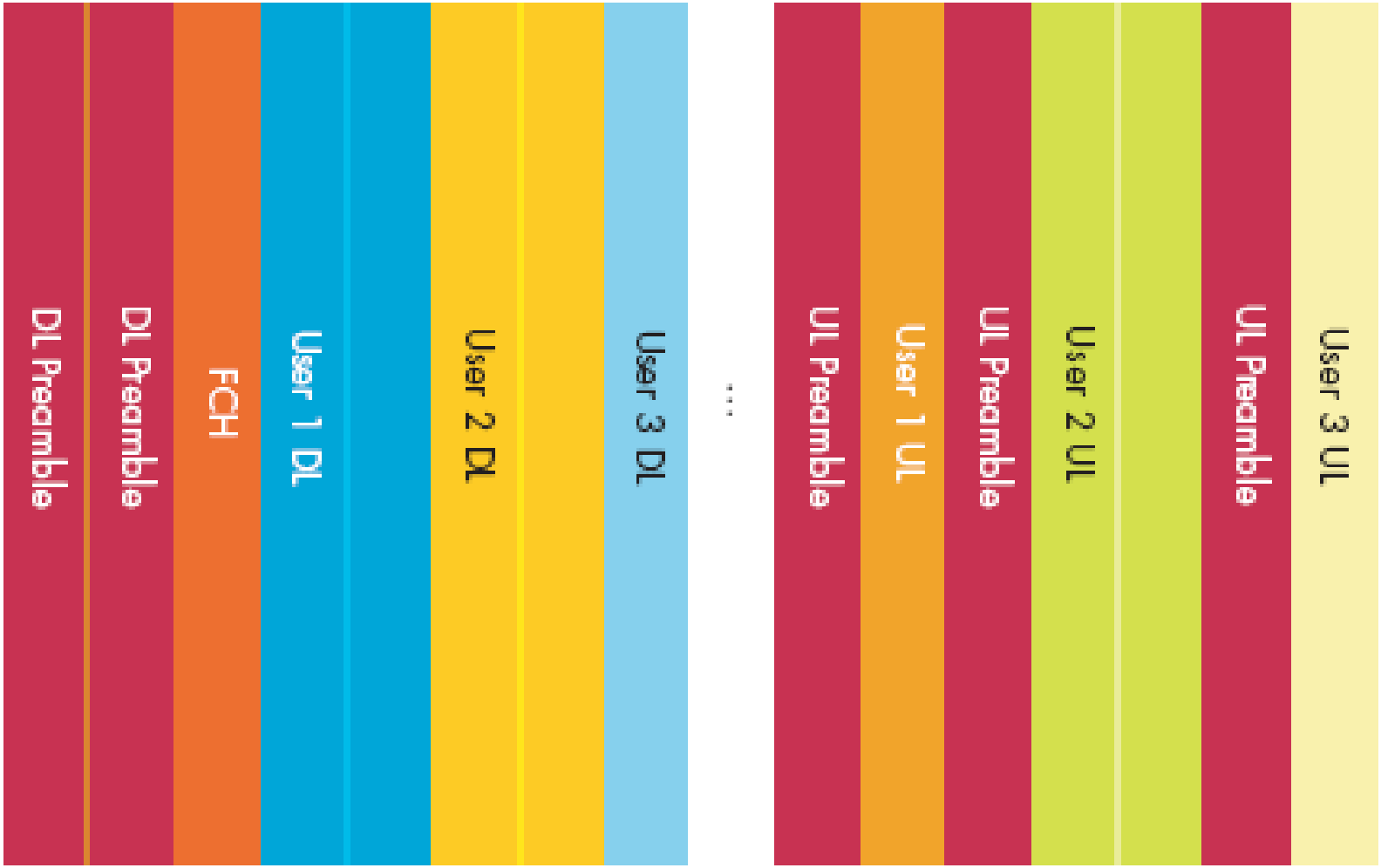
OFDMA: Orthogonal Frequency Division Multiple Access

Alcatel source

WiMAX performance

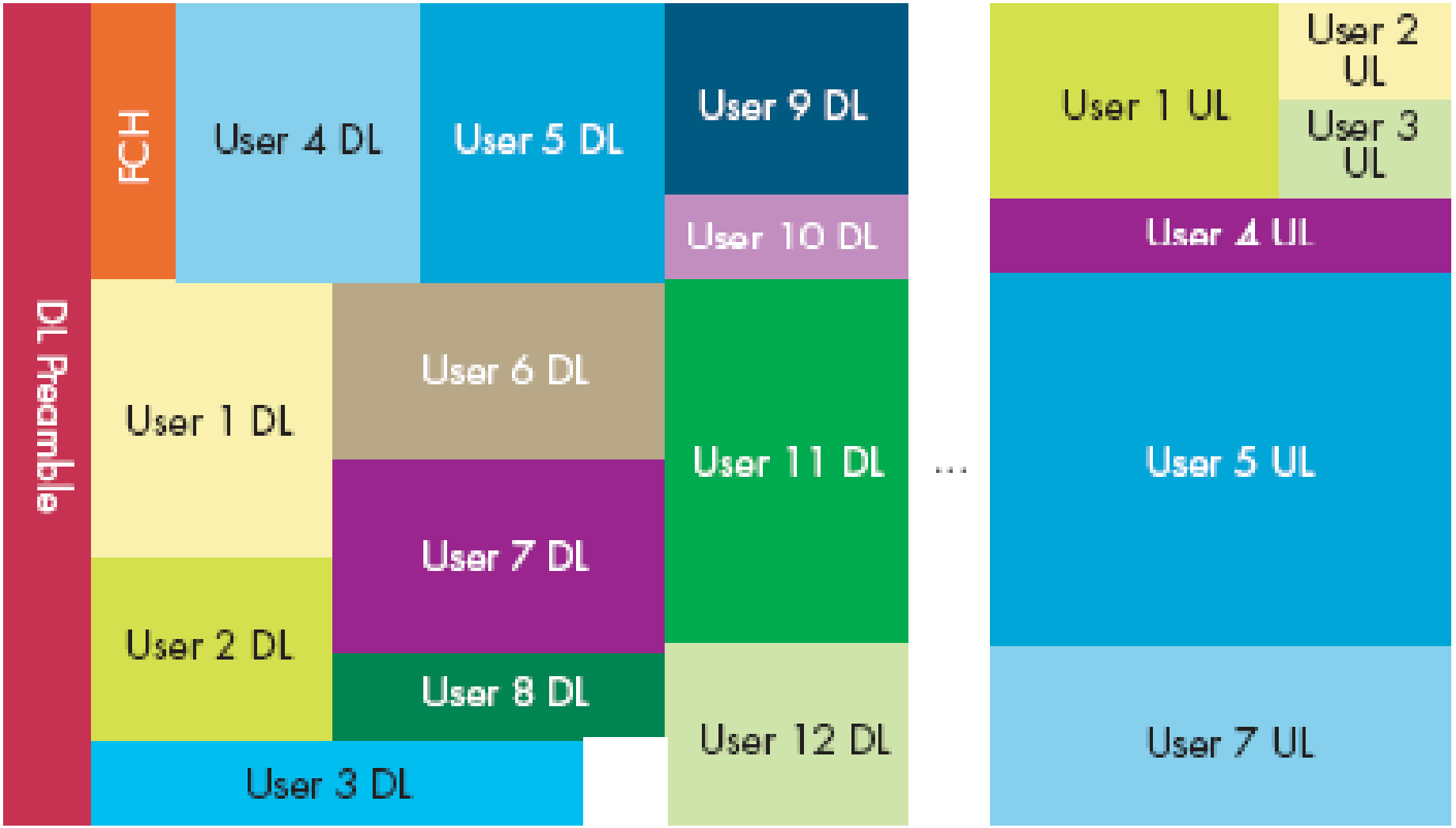
- Point to multipoint
- 50 km at 70 Mbps in theory
- 10 km with 30 Mbps

WiMax 2004 Frames



Alcatel source

Frame IEEE 802.16e –WiMax Mobile



Alcatel source

WiMAX classes

Services	Definition	Application	Bandwidth Stealing	QoS Parameters
Unsolicited Grant Service (UGS)	Real-time data streams comprising fixed-size data packets at periodic intervals.	T1/E1, Voice	Not Allowed	Maximum Sustained Traffic Rate–Minimum Reserved Traffic Rate, Maximum Latency Tolerated Jitter Request/Transmission Policy
real time Packet Service (rtPS)	Real-time data streams consisting of variable-sized data packets that are issued at periodic intervals.	MPEG, Video	Allowed	Minimum Reserved Traffic Rate Maximum Sustained Traffic Rate, Maximum Latency Traffic Priority Request/Transmission Policy
non real time Packet Service (nrtPS)	Delay-tolerant data streams consisting of variable-sized data packets for which minimum data rate is required.	FTP	Allowed	Minimum Reserved Traffic Rate Maximum Sustained Traffic Rate, Traffic priority Request/Transmission Policy
Best Effort (BE)	Data streams for which no data minimum service level is required.	HTTP	Allowed	Maximum Sustained Traffic Rate Traffic Priority Request/Transmission Policy
enhanced real time Packet Service (ertPS)	Real-time service flows that generate variable-sized data packets on a periodic basis.	VoIP with silence suppression	Allowed	Maximum Sustained Traffic Rate Minimum Reserved Traffic Maximum Latency Request/Transmission Policy

Alcatel source

WiMAX mobile - IEEE 802.16e

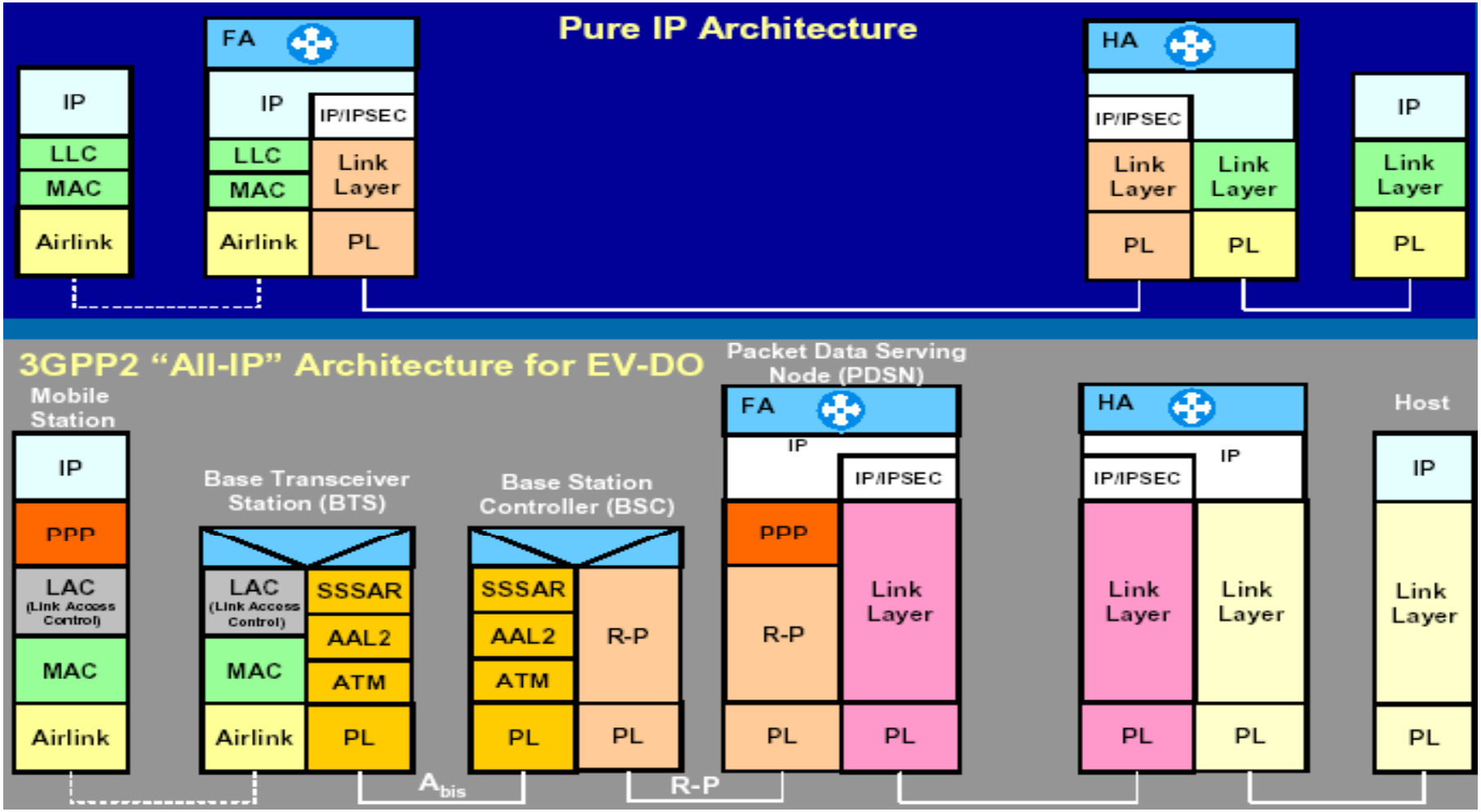
- **Specification for the WiMAX mobile**
  - Frequency < 3.5 GHz
  - Data: 1 to 4 Mbps per user
  - Speed up to 130 km/h
  - Large cell (approximately 1 km)
  - Ambient network
  - QoS Garanty
  - Security with EAP-TLS smartcard

IEEE 802.16e WiMax Mobile

Mobile Device Categories

- Notebooks / Tablet PCs
- Information (Internet) Appliances
- Personal Digital Assistants / Handhelds
- Smart Phones
- Pagers / Two-way Messaging Devices
- Phones

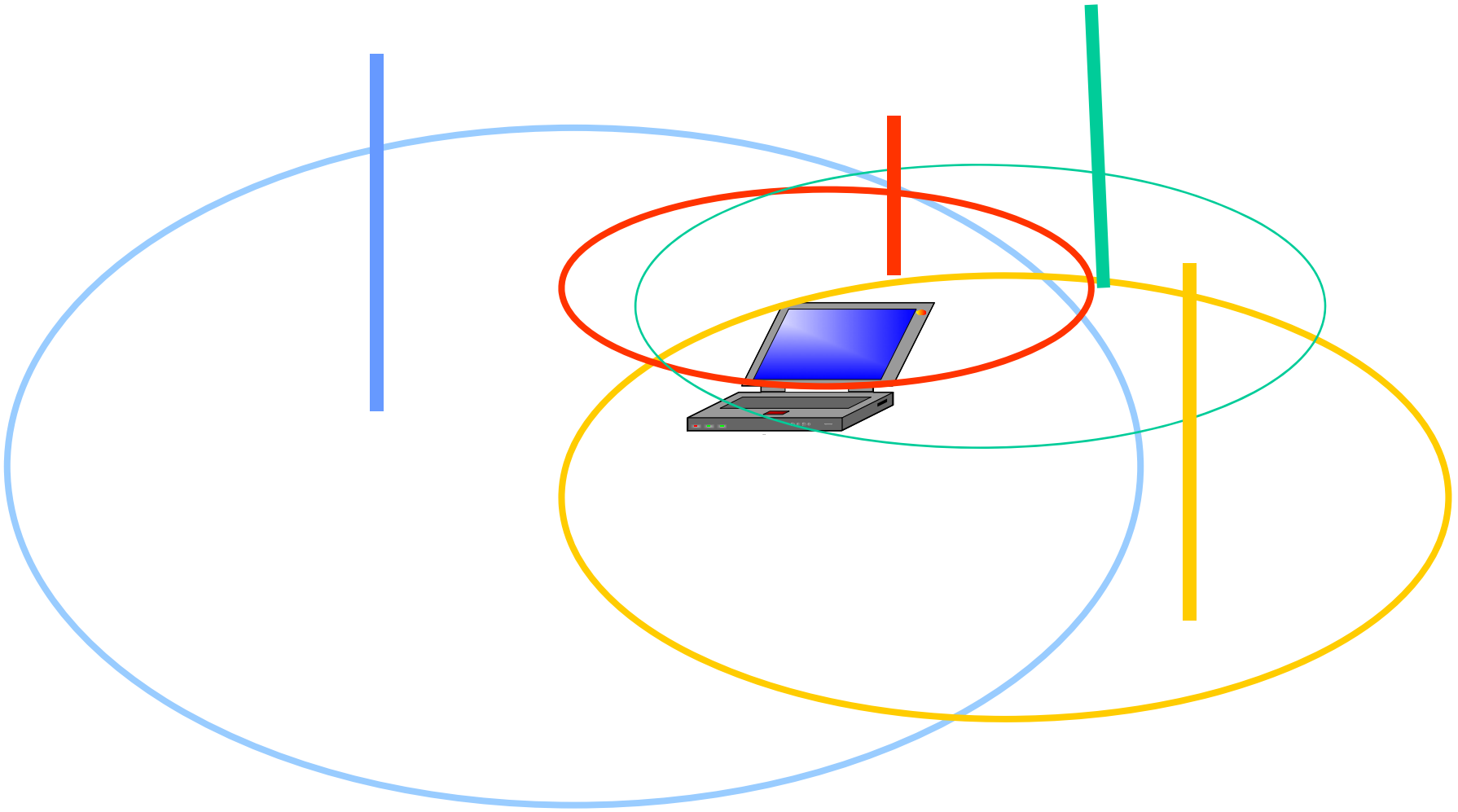
Architecture IEEE 802.16e vs 3GPP2



Centrino

- **IEEE 802.16-2004**
- **Intel products**
  - Rosedale
  - Centrino 3
  - Centrino 4
  - Centrino 5
  - Centrino multihome

Multi-technologies and multi-homing



WiRAN : 802.22

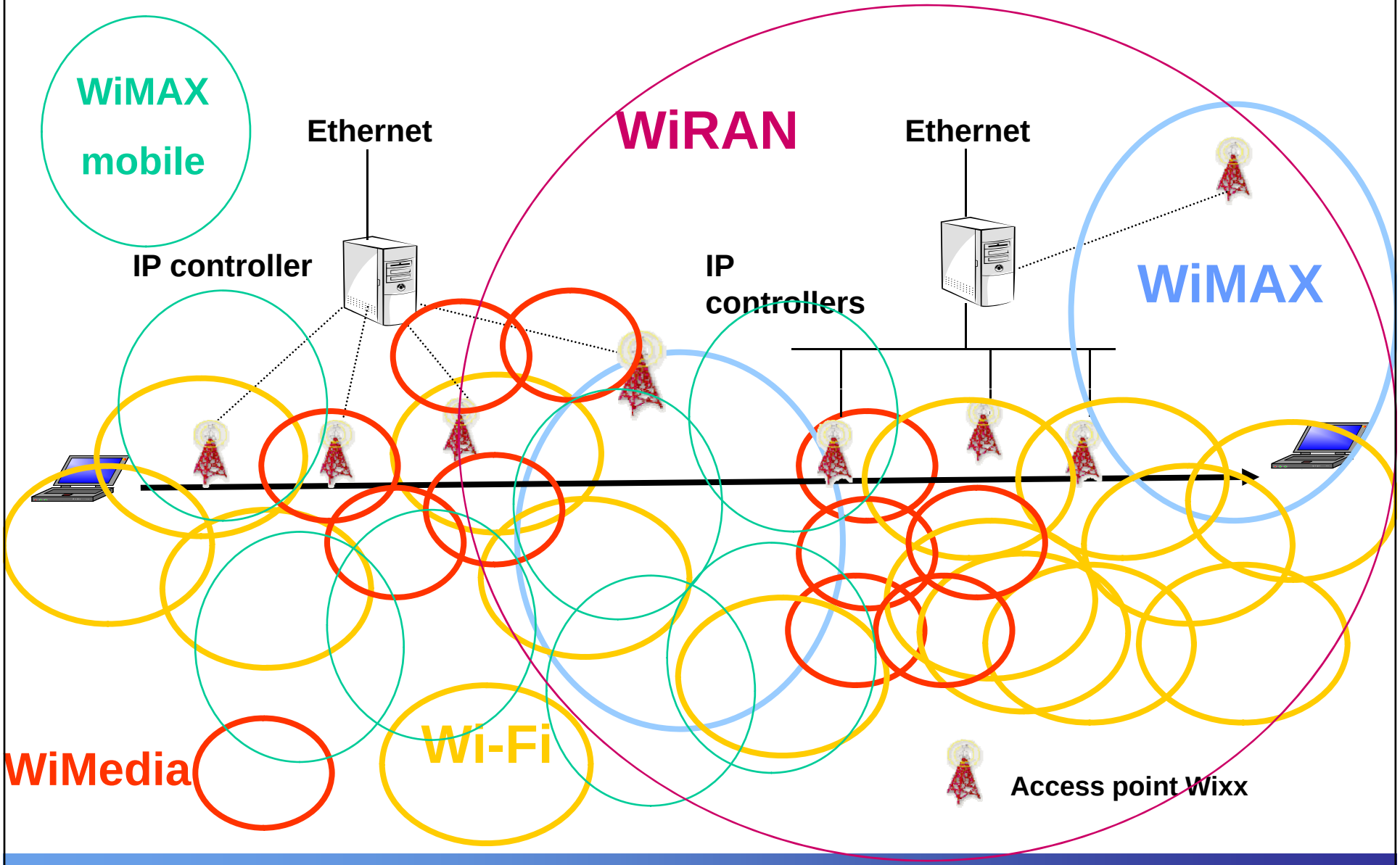
- **Band: 300 MHz within the 54 – 862 MHz television band**
- **Cognitive radio**
  - Free license
- **Channel: 6 or 8 MHz**
  - Throughput : 18 Mbps for a 6 MHz channel
  - User speed from the antenna: 1,5 Mbps to 4 Mbps
  - User speed from the terminal: 384 kbps but may be 64 kbps
- **Power: 1 W antenna, 100 mW terminal**
- **Transmission technique**
  - OFDM
- **QoS support at the MAC layer**
- **Very low price**

IEEE 802.22

- **The terminal has not to be declared (free license)**
- **Radio characteristics are controlled by the sender**
- **GPS/Galileo to determine the frequency to be used**
- **Range: 50 kilometers**
- **Bandwidth: 300 MHz**
- **With a cognitive frequency choice:**
  - telephone+ data 100 000 clients
  - only telephony 1 000 000 clients

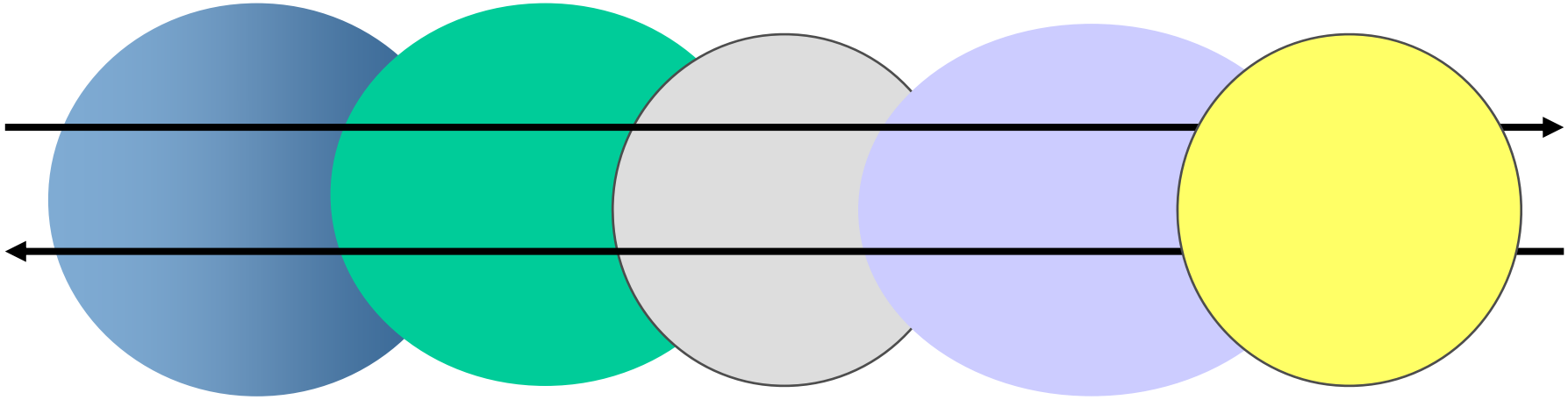
Wireless Internet

Wireless Internet



IEEE 802.21 Media Independent Handoover Scheme

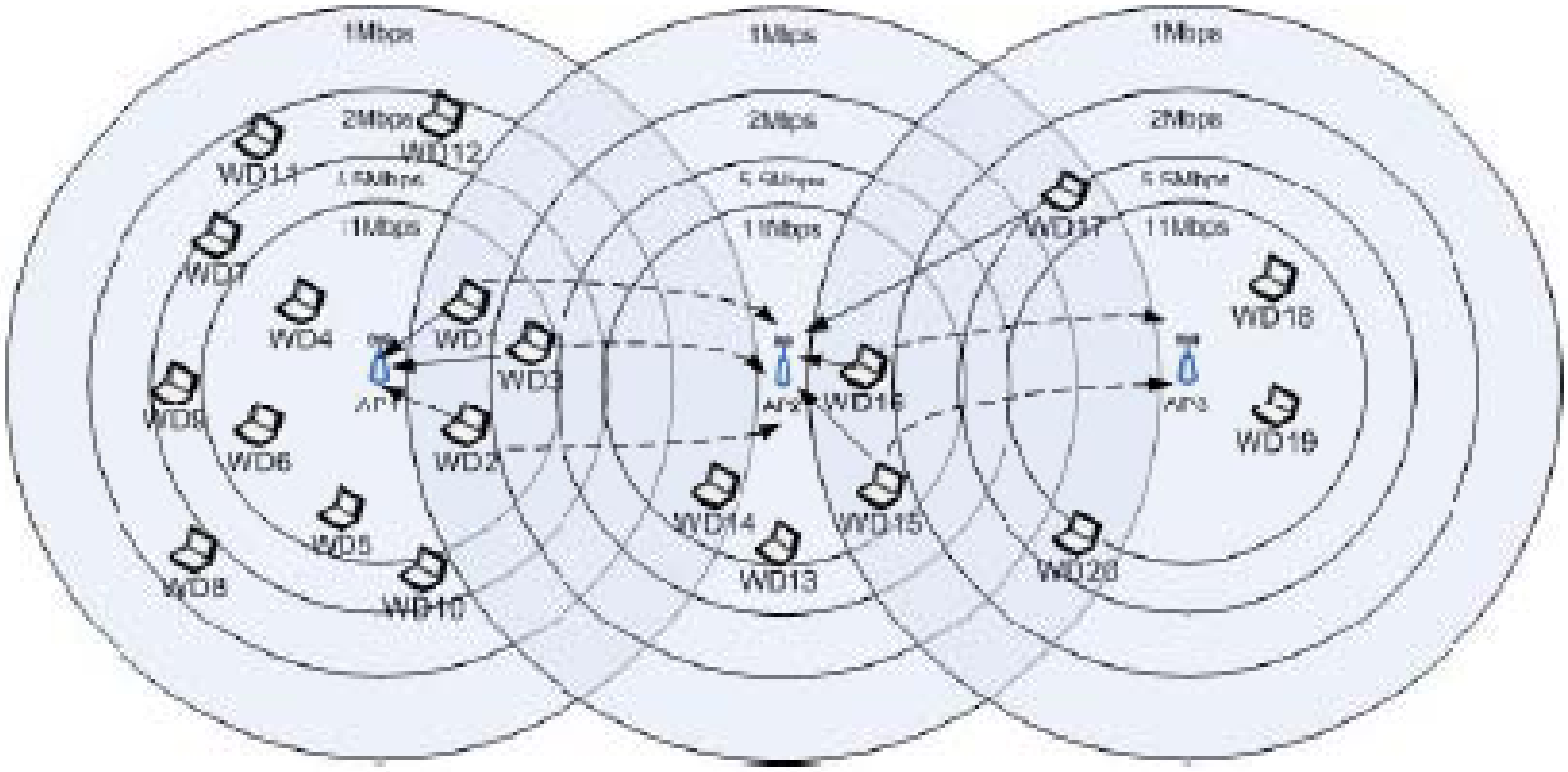
- Handover between the different 802 standards (802.15, 802.11, 802.16, 802.20, 802.22)



WiMedia, Wi-Fi, WiMAX, Wi-Mobile, WiRAN

Performance analysis

The model under simulation



Wi-Fi Networks

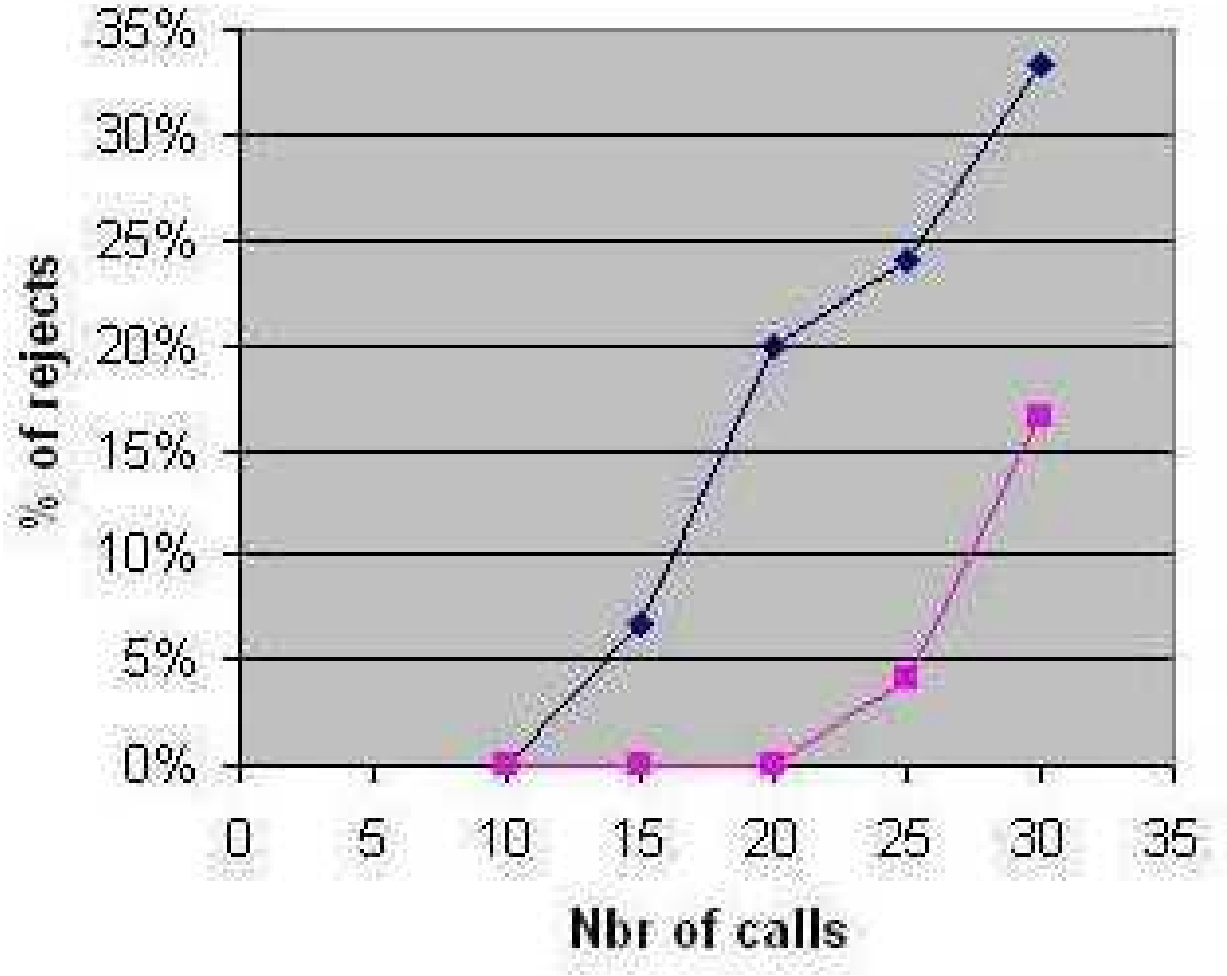
Parameters

- **VoIP traffic**
  - G711 codec

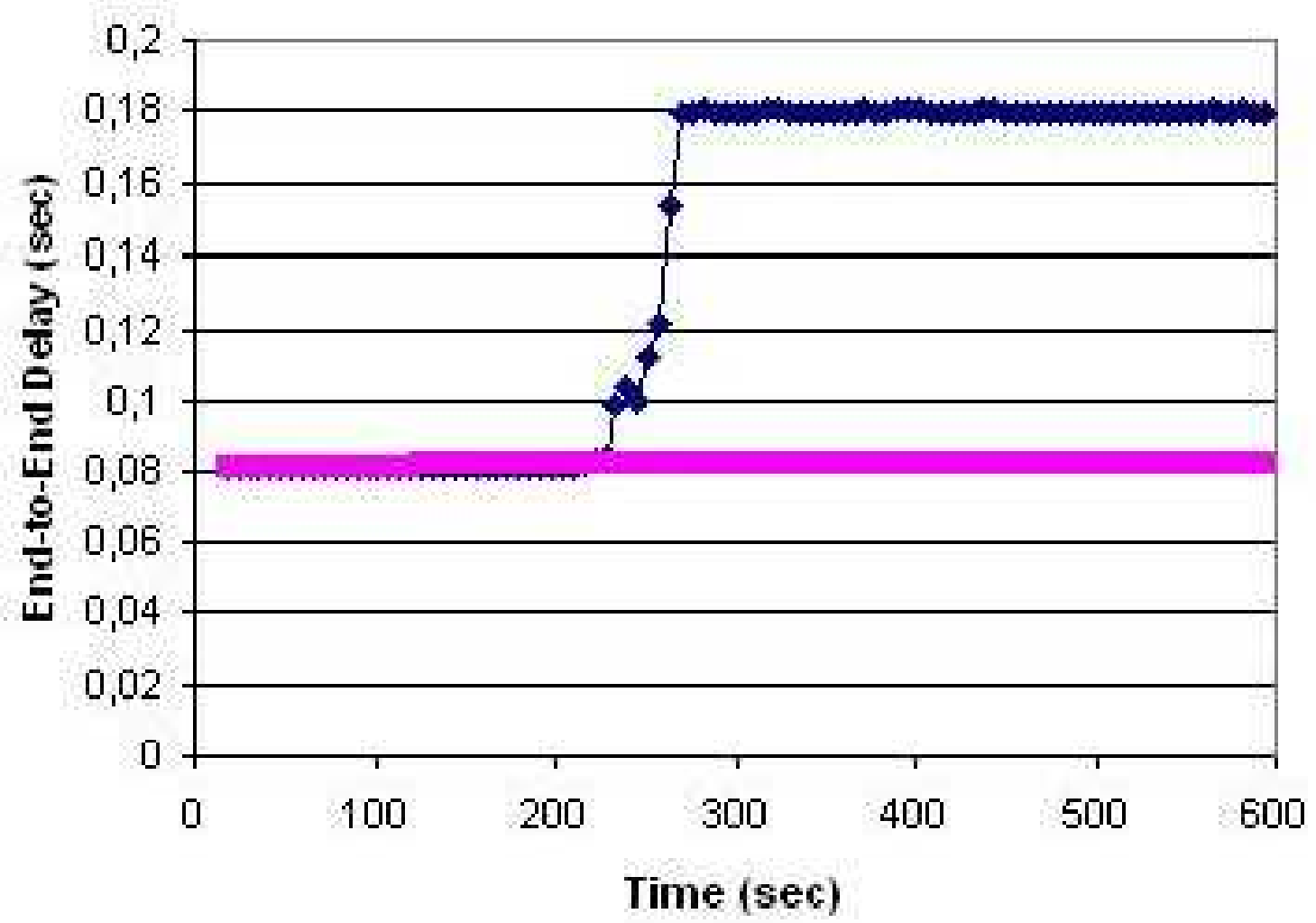
Bit Rate (Mbps)	11	5.5	2	1
Throughput (Kbps)	1600	1450	1120	800
# of connections	10	9	7	5

- **Wi-Fi – IEEE 802.11b**
  - Rate dependant on the position
- **OPNET**
  - A call every 10 seconds up to a maximum number n
  - 5 < n <35
  - When a call is rejected a new call arrives after the time-out
  - When a call is finishing after 100 seconds, a new call is entering at a random point

Proportion of rejected calls

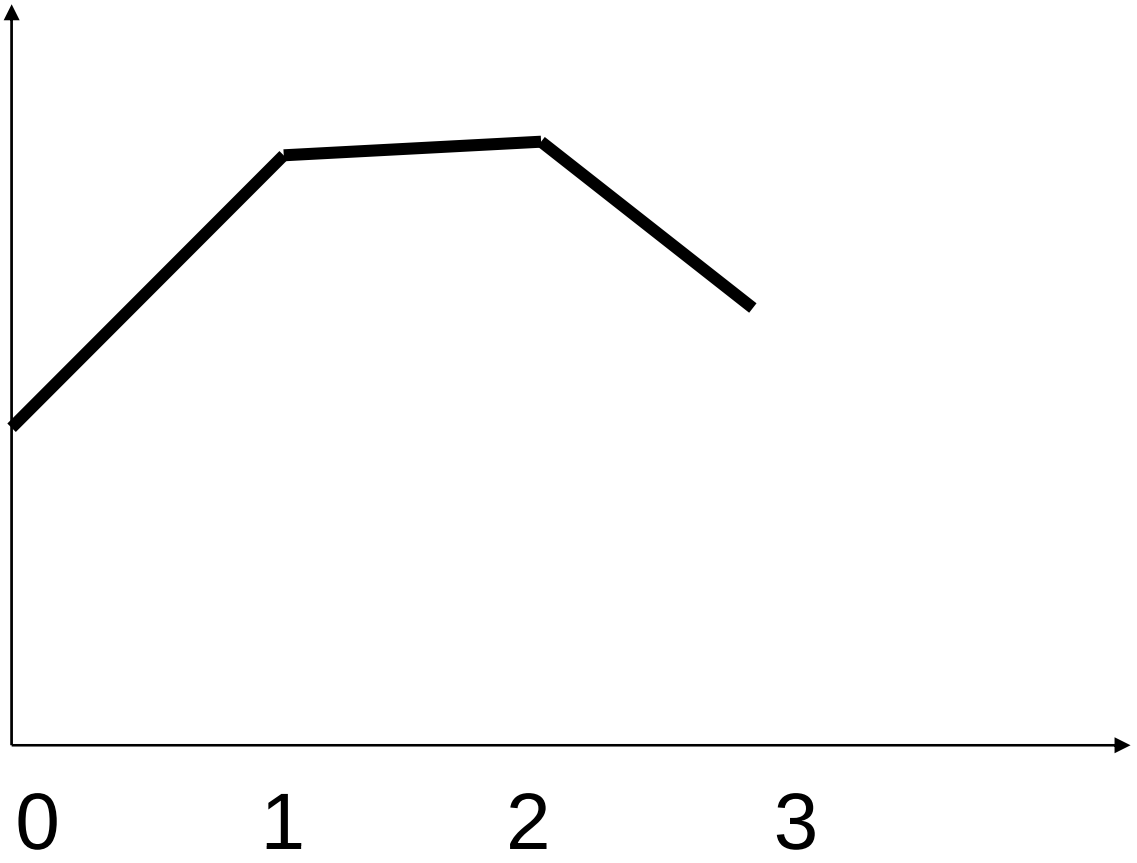


End-to-end delay



Simulation results

- **The situated view**



Conclusion

- **Autonomic networks**
  - Piloting plane
- **Virtualization**
  - Passage to a new age