Programmable/Active Networks - a network infrastructure for next generation GRIDs

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Outline

- The Grid
- Network Implications
- Programmable Networks
- Virtual Networks/Virtual Network Service & the GRID

The Grid

- Driven originally by high energy physics community
- Distributing/managing/processing a high volume of data to a small number of sites round the world
- Globus is the current middleware used by most Grid projects (described by some as shell scripts to do secure remote job entry)

The Grid: What's Interesting ?

- Large scale distributed computing and networking
  - Lots of computers where "involvement" is dynamic but where resources must be allocated intelligently / Not big supercomputers
  - Large Networks
- Discovery of information, understanding of information, assurance of information
- Virtual organisations, conflicting and multi-domain administrative, security, or management models
- Rapid deployment of applications/ services
- Some applications…

The Grid: What's Challenging for "Infrastructure"?

- Higher capacity demands
- Higher reliability
- No longer just the elephants and the mice?
  - Need for better resource management
  - Need for better performance monitoring
  - Need for self-provisioned and dynamic SLAs
  - Need to open up control
- Provision of Computational Platforms with guaranties
- Provision of Networking Resources with guaranties
- Autonomous and rapid provisioning of applications / services

Network, Storage, Computational Resource Management

- Need a better handle on what's going on
- Need better handle on user utility (no longer just the elephants and the mice.)
  - Eg DiffServ with automatic SLA provisioning
- FCAPS management of resources (network, storage and computational resources)
- .....

Grid and Dynamic Virtual Networks

- Virtual Network -"Looks like a network" (QoS VPNs) to those who are members and it has real resources and can give guarantees
- One of the aims was for safe network programmability (control your own virtual network but no one elses)
- Want the ability on various timescales (the smaller ones are more interesting) to configure a subset of network resources to support a particular application.
- Virtual organisation maps to virtual network

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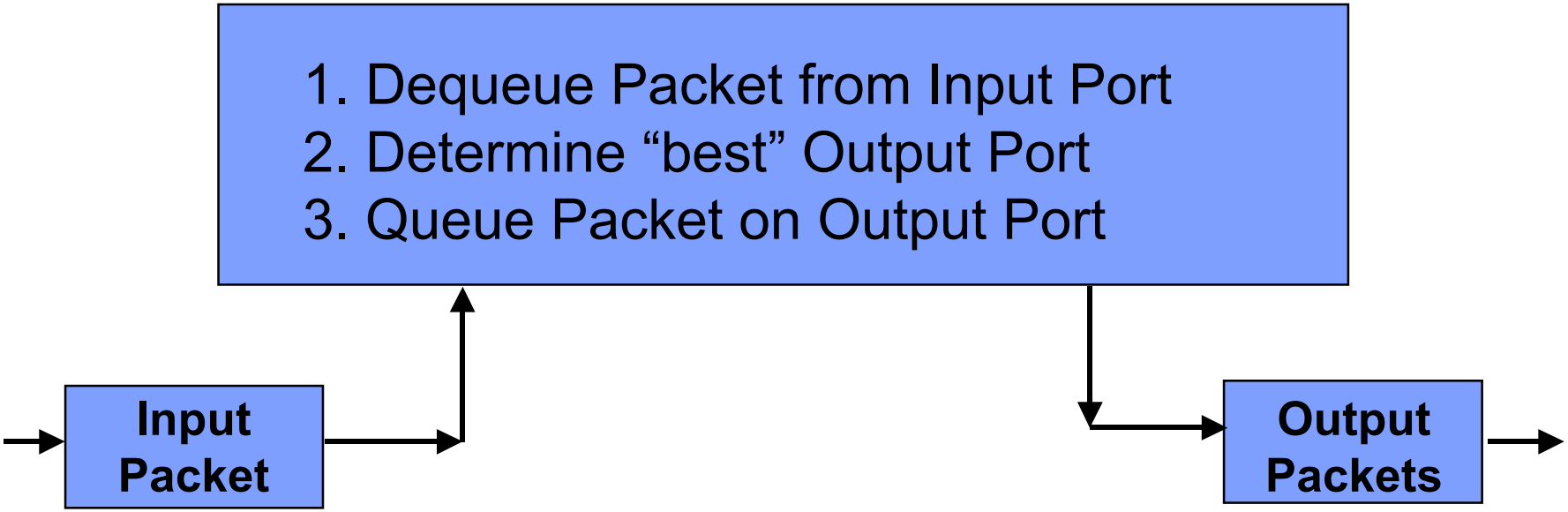
Introduction to Programmable/Active Networks

Presently in IP networks,

- routers (nodes) examine destination addresses, then determines which neighbour to forward the packet
- smart hosts on network edges, connected by routers
- network **APIs** define **virtual machine** that interprets a specific language for the **Internet Protocol (IP)**
- **limited** values can be placed in that field in the IP header of a packet
- **limited** user control over network's behaviour

Present IP Packet Routing

- Model: Store and Forward



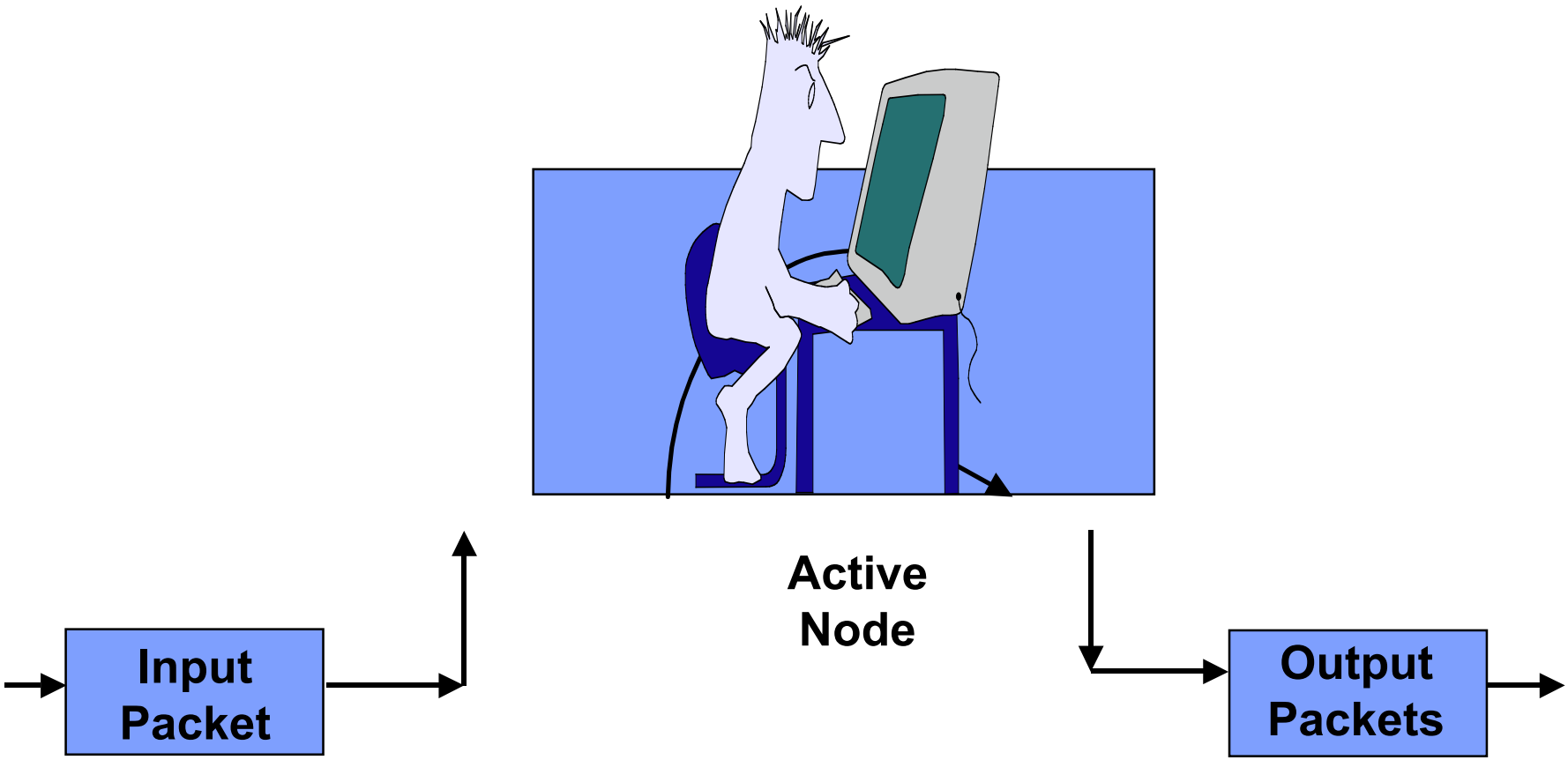
Introduction to Active Networks (cont'd)

Active Networks,

- routers (nodes) extensively programmed by the packets passing through them, under the end-user's control
- intermediate routers perform computations up to the application layer
- seen as providing programmable network
- if IP header seen as input data to virtual machine, packets in active networks contain programs as well as input data

Active Node Packet Routing

- **Model: Store, COMPUTE and Forward!**



Programmable/Active Networks

- Active/Programmable Networks is about programming the network infrastructure to support customised communication services
  - **Active = dynamic programmability and control**
  - **Customisation = user/consumer centric network and services**
  - **Store - Compute - Forward**

- Expected major impact: rapid service/application creation and deployment

Main Issues : Active vs Passive

- Computation in the network
- Users can introduce programs
  - **delegate control and responsibility**
- Improved utility
- Improved resilience to change

- Greatly improved flexibility

- …. but increased risks from sharing control

Balance between Flexibility and Safety

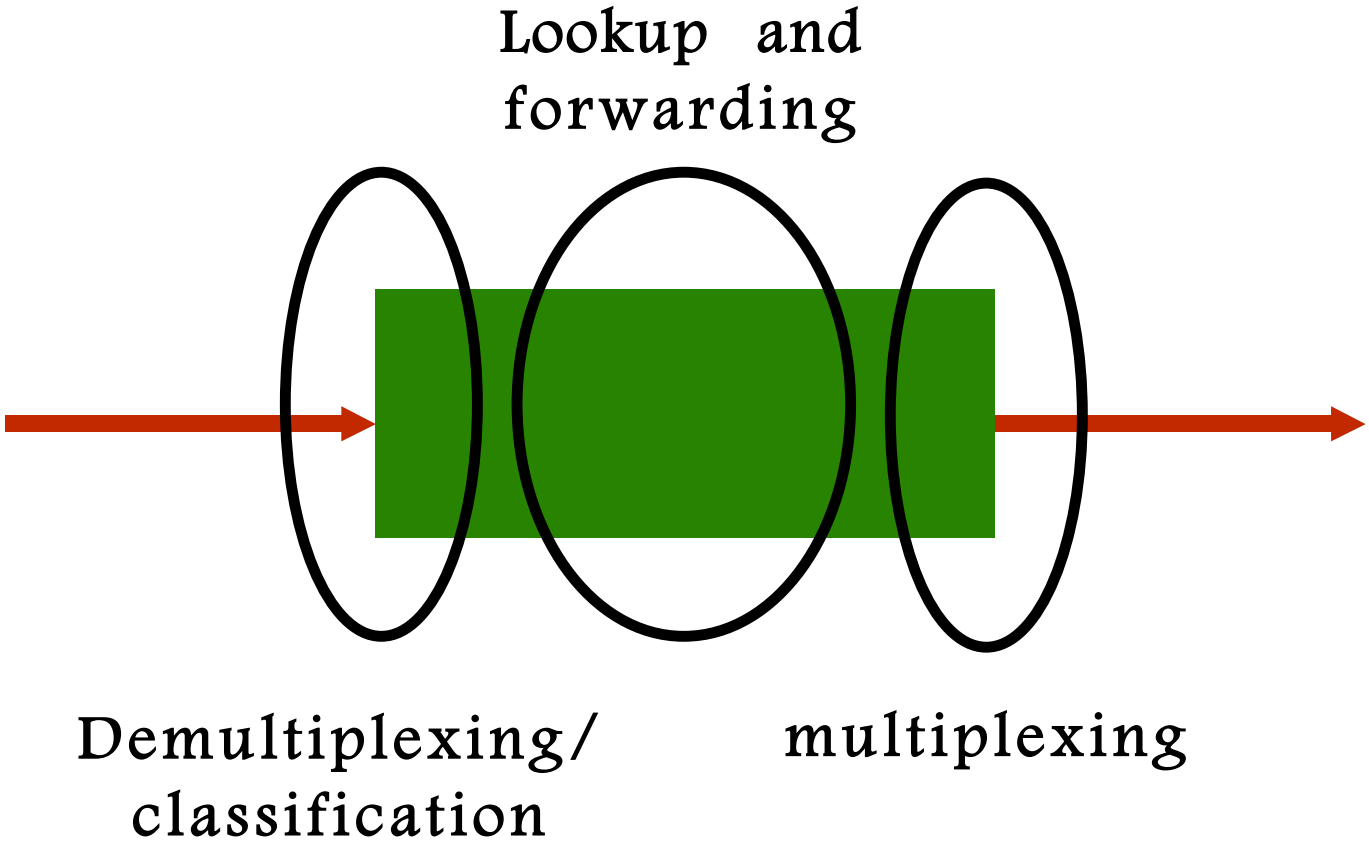
Main Issues (II) : Where to put the activeness/programmability ?

- Service layer (active service programmability)
  - lower performance
  - high flexibility and complexity
  - autonomic & dynamic reconfiguration of resources
  - local & global self organisation
- Edge Router (active server programmability)
  - lower node performance
  - higher flexibility
  - evolution straightforward
- Router OS / Kernel (active network programmability)
  - potentially high node performance
  - harder to manage and make secure
  - contaminates fast data path
  - longer term evolution

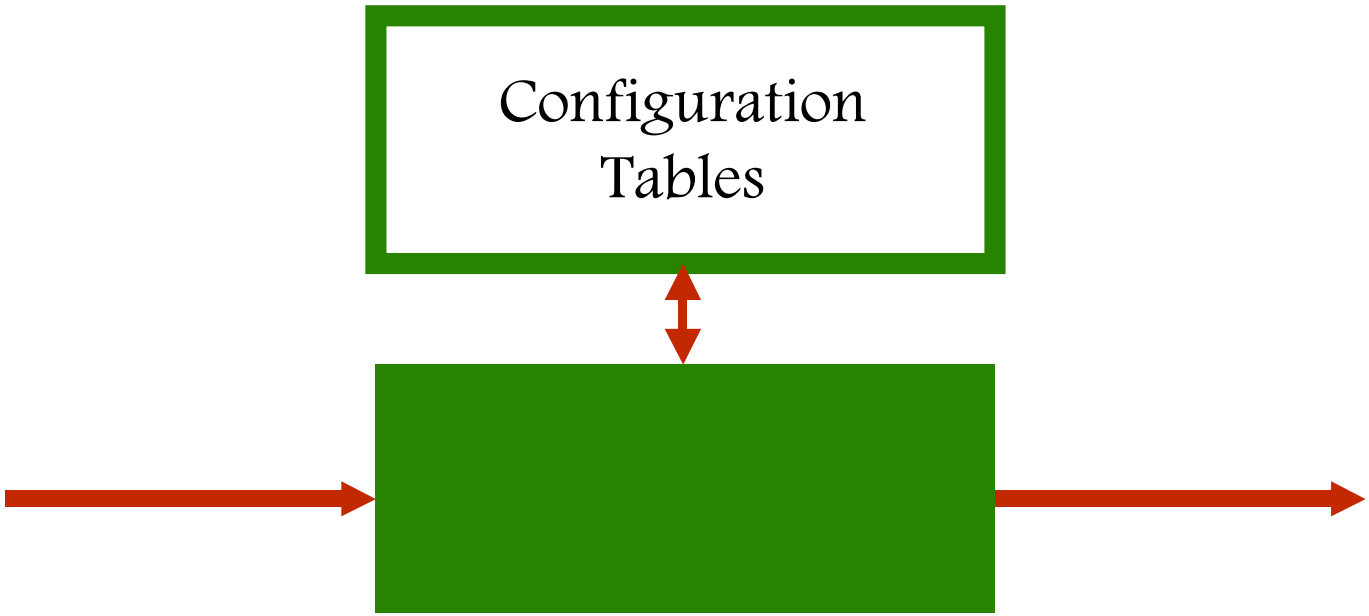
Performance vs Safety vs Flexibility vs Usability

Programmability Vs Autonomy Vs E2E view

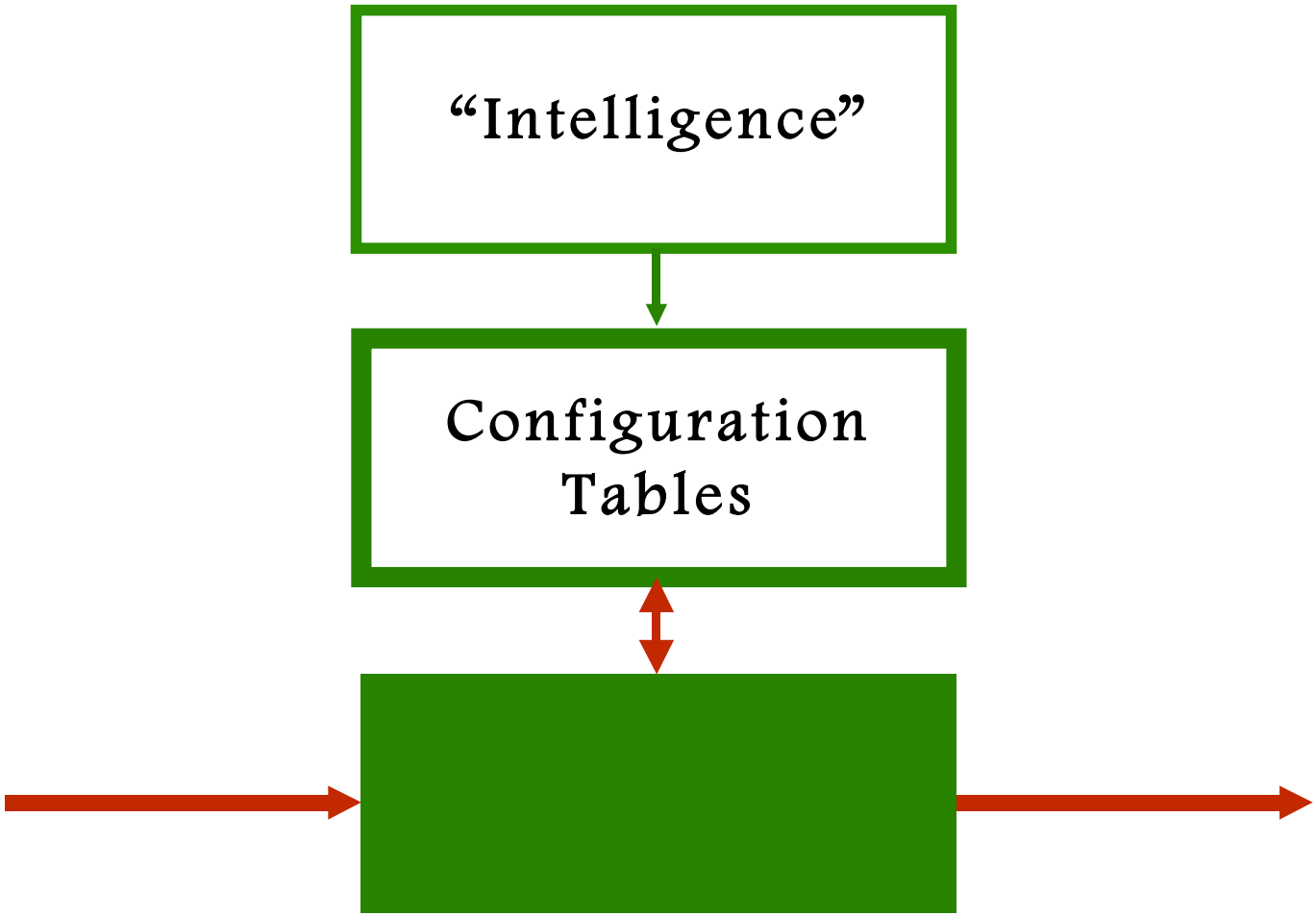
The Data Path



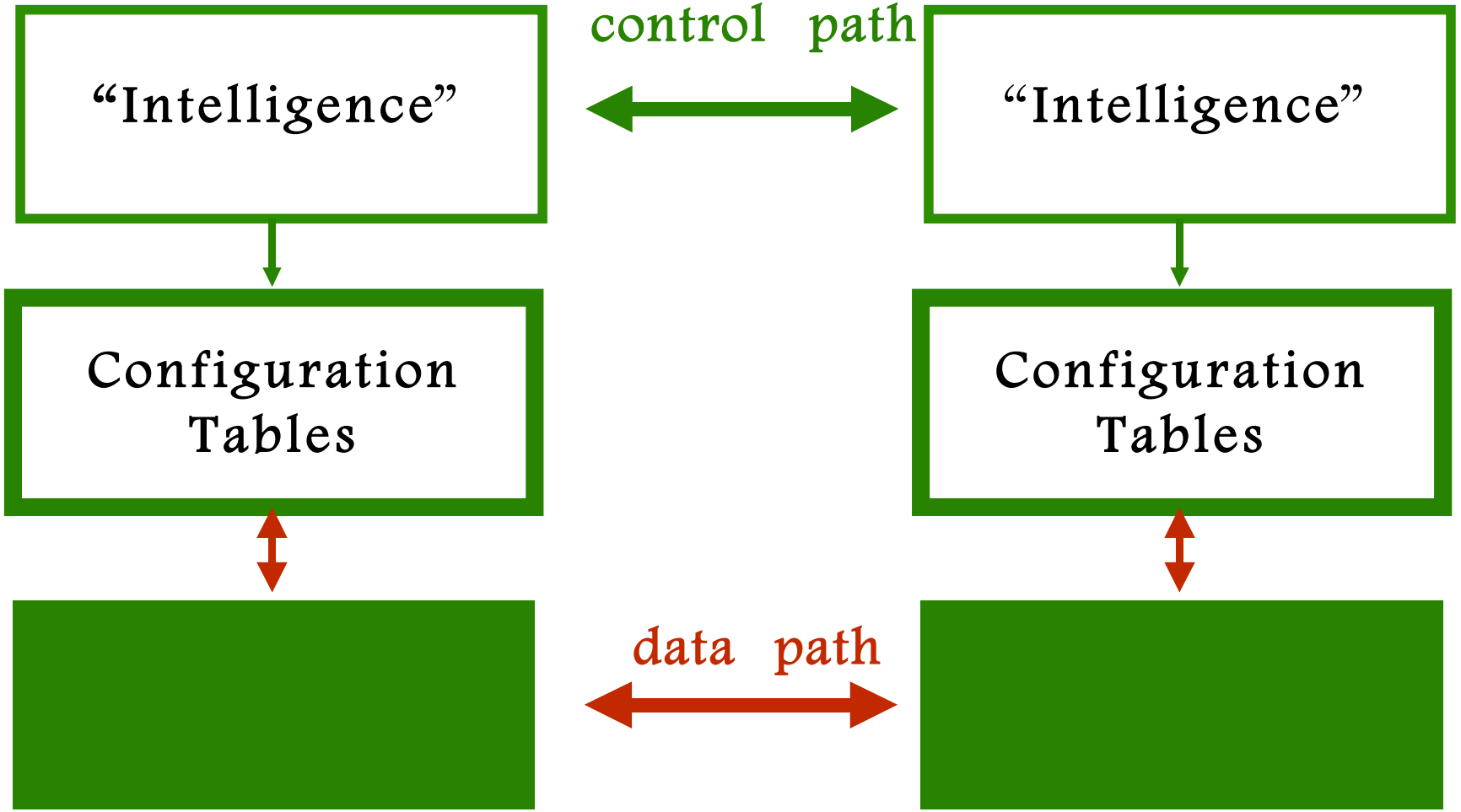
Configuration



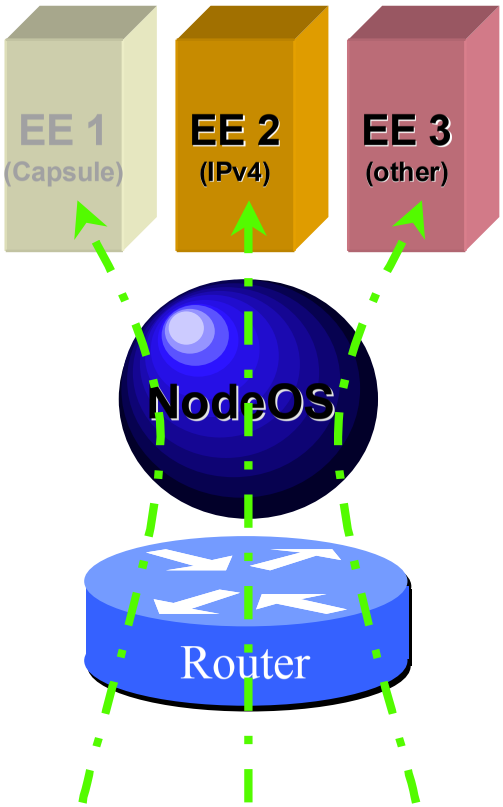
Control



Control Path



Active Node : Alternative Perspective



Execution Environments

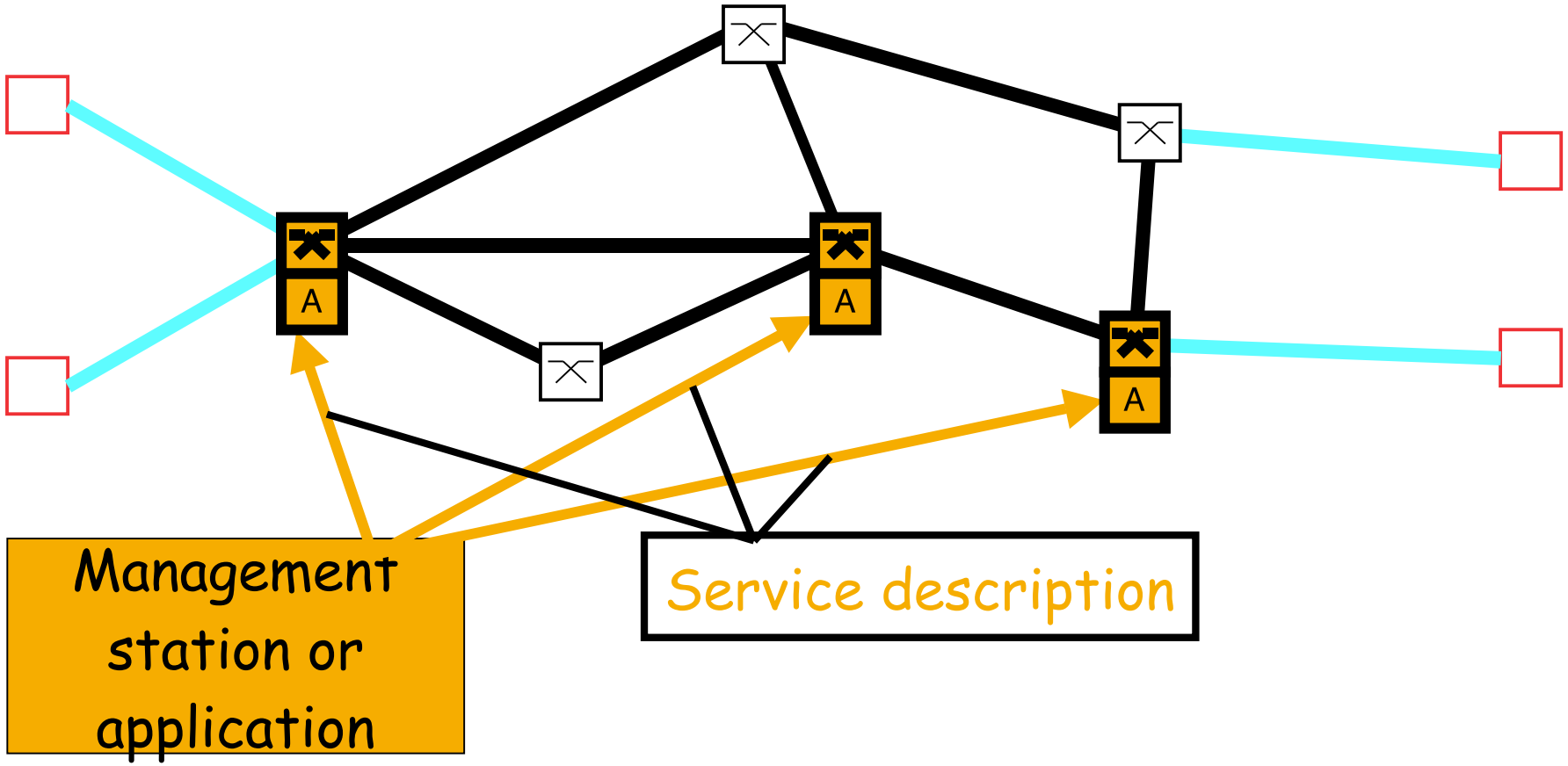
- Implementing different Network APIs
- Each network API contains a composition mechanism for service creation
- Network APIs go beyond static APIs taking the form of a programming language.
- Within EEs different programming methodologies and network technologies are realised

Node OS

- Resource Management & Control
- Security Enforcement Engine

Hardware (Physical resources)

Network-wide service deployment



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Using Dynamic GRID VPNs

- Resource partitioning (networking, storage & computational resources; VPN SLAs)
- Can move resource dynamically between virtual networks (eg time of day, disaster recovery)
- Can have relatively short lived virtual networks

Building GRID VPNs

- Take a specification of a VPN:

  endpoints, traffic matrices, reliability, etc, Control Policy, Services

- Allocate resource and create dynamically the link service-to-resources, find computational resource and instantiate Control Policy

Some key GRID VPN Issues

- Useful to think of four activities
  - Control path configuration
  - Component control for resource partitioning
  - Network resource management
  - Computational Resource management
  - Virtual Network Service Provision

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[7] Galis, A., Denazis, S., Brou, C., Klein, C. (ed) – book " Programmable Networks and Programmable Network Management " ISBN 1-58053-745-6 ; contracted for publishing in Q4 2003 by Artech House Books, 46 Gillingham Street, London SW1V 1AH, UK; www.artechhouse.com

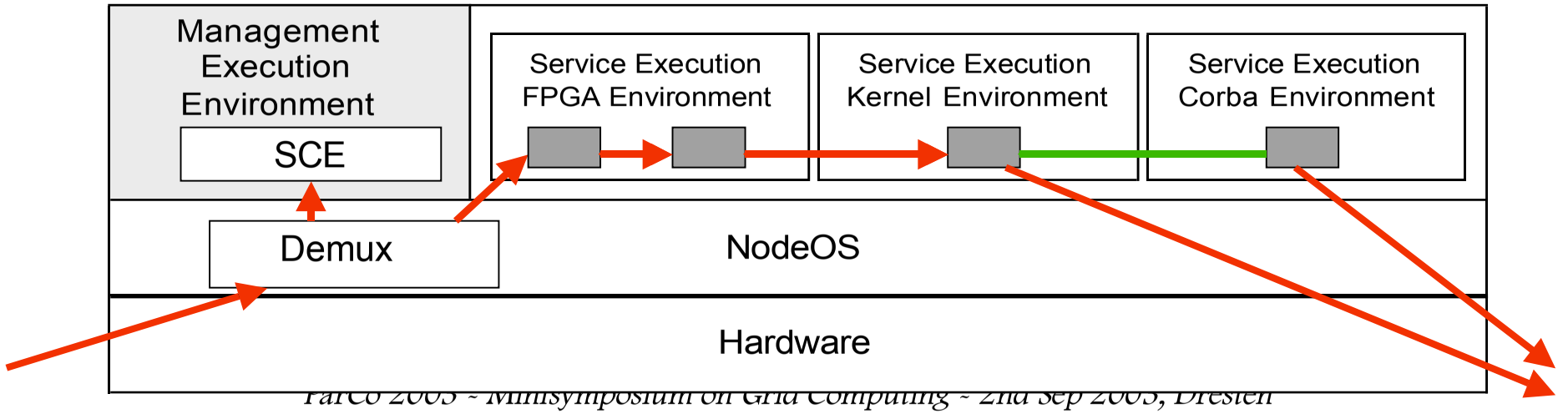
[8] FAIN project www.ist-fain.org

[9] CONTEXT project http://context.upc.es/

Thank you for your attention

Active Node Model

NodeOS



Node-local service deployment

Service model

- Component based

Node local service deployment mechanism

- Resolution of the node independent service specification to a node specific service implementation
- Resolution controlled by the node

Demultiplexing, resource control

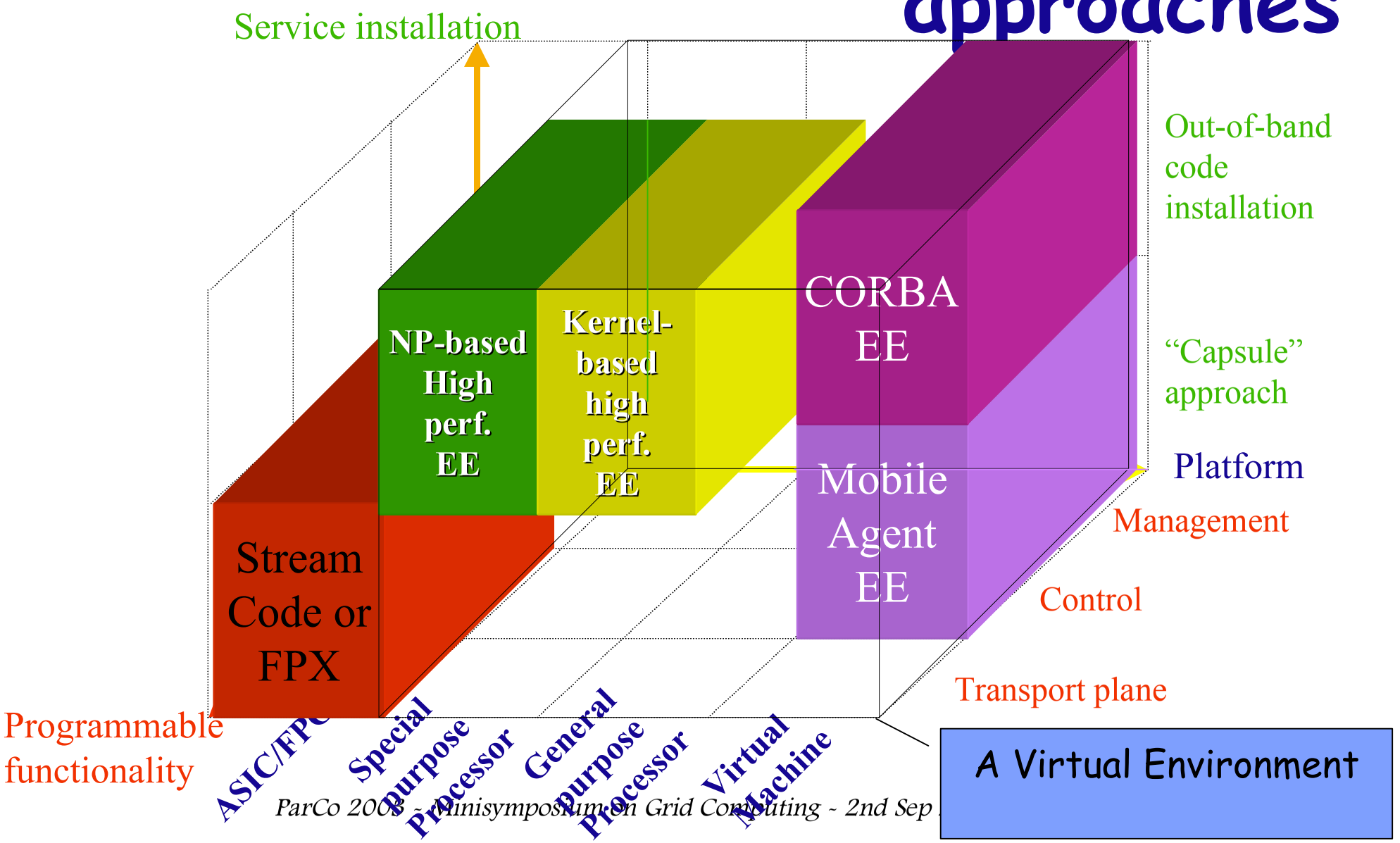
Management EE

- Service Creation Engine (SCE) loads and configures service components according to service spec
- Instantiates and manages service EEs and configures nodeOS

Service EE

- Runs service components
- Provides a particular programming model (user space / Java, kernel / C, reconfigurable HW / VHDL)

A taxonomy for Active Nets approaches



Programmable GRIDs
Key Characteristics

	Programmability	Autonomy	e2e View
	Network modification	Enablers for modification	Dynamic Enablers & net modification
Results	Reconfigurability	Autonomic reconfiguration	Dynamic reconfiguration
Target	Net modification	Node modification	Net & Node Dynamic modification
Systems	Peer layers/overlays	Top Down Layered Overlays	Top Down & Vertical Layered Overlays
Initiated by	Net requirements for change	Service requirements for change	Business requirements for change
Inter-operability	Network Components	Node components	Service, Net, Node Components
Driven by	Local/global system optimization	Local / global self-organization	Business organization