Active Networks

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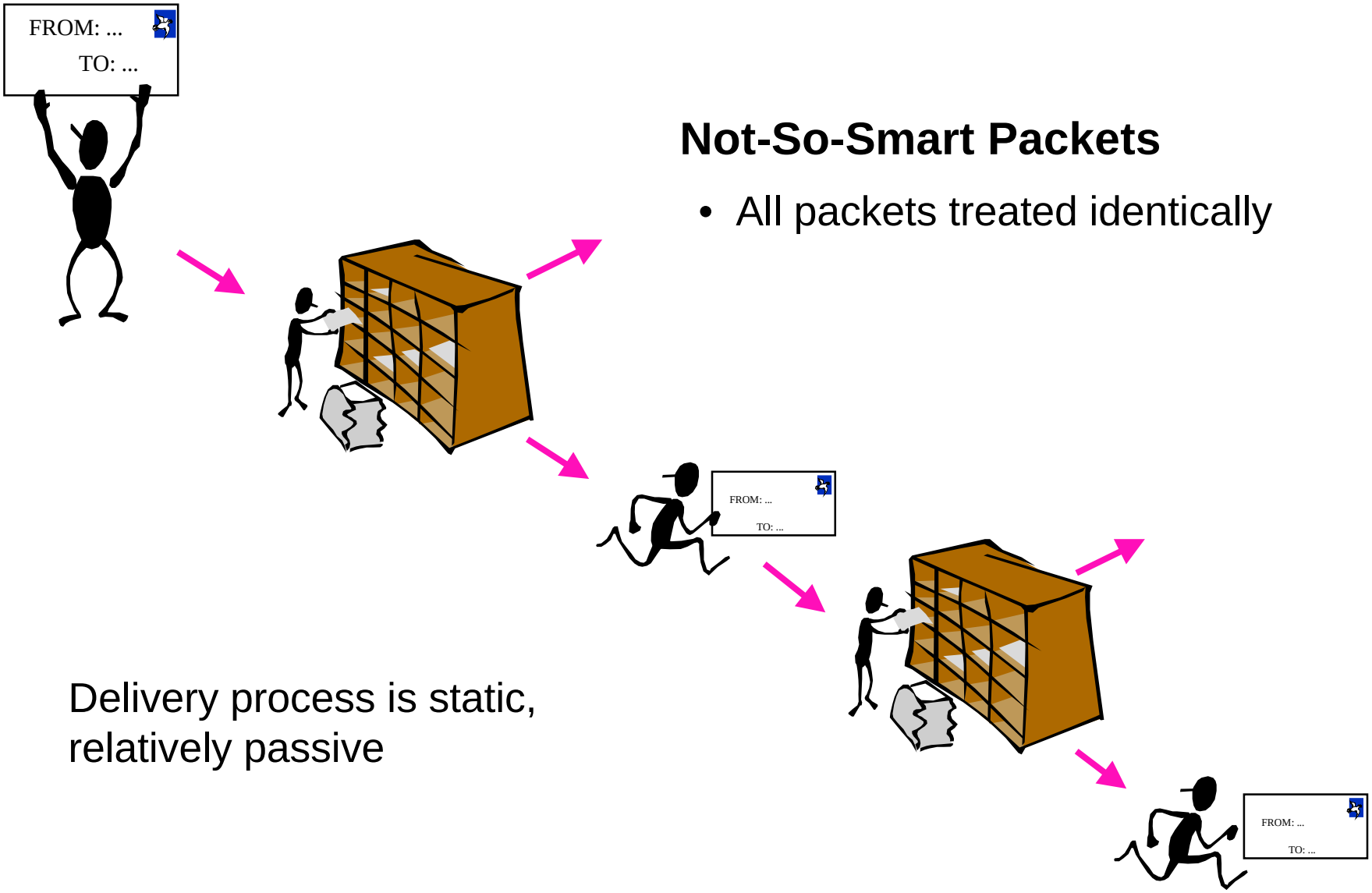
ACTIVE NETWORKS: TODAY'S INTERNET

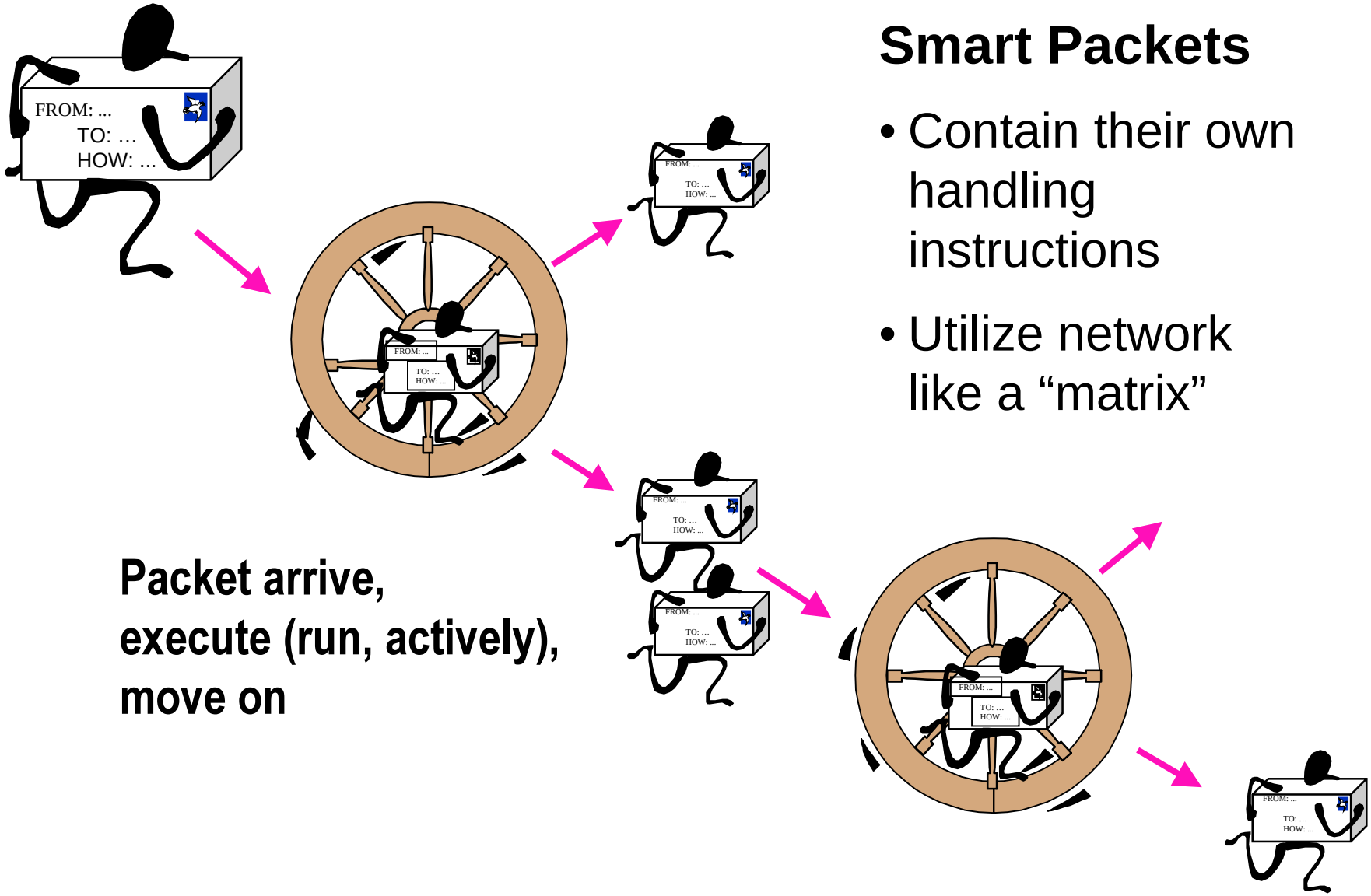


Not-So-Smart Packets

- All packets treated identically

Delivery process is static, relatively passive

ACTIVE NETWORKS



Smart Packets

- Contain their own handling instructions
- Utilize network like a “matrix”

Packet arrive, execute (run, actively), move on

WHAT THE INTERNET CAN AND CANNOT DO

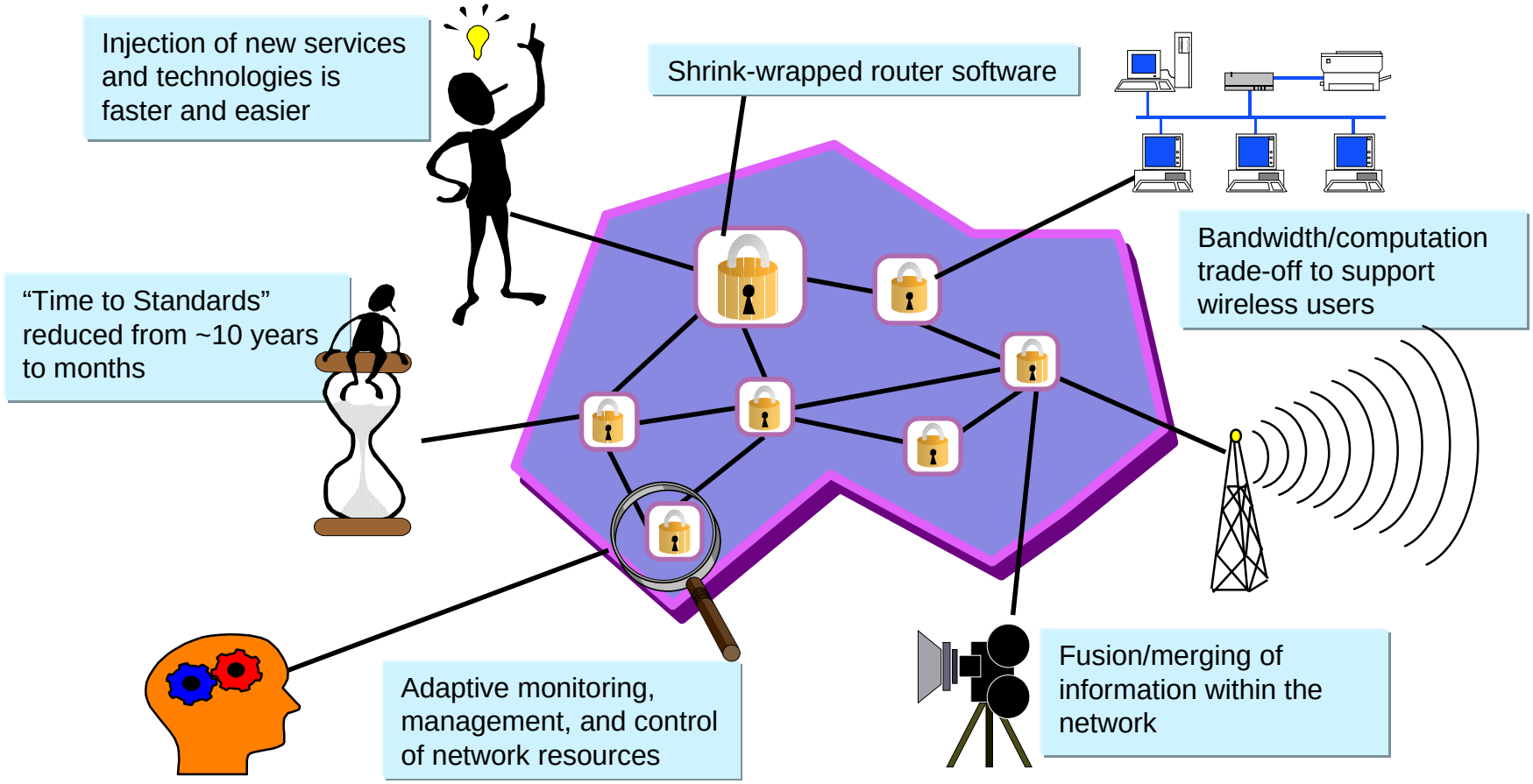
We Can:

- Support new, emerging applications
- Add limited security layers, i.e. firewalls
- Pretend that mobile hosts are static
- Multicast to similar end-user equipment

We Cannot:

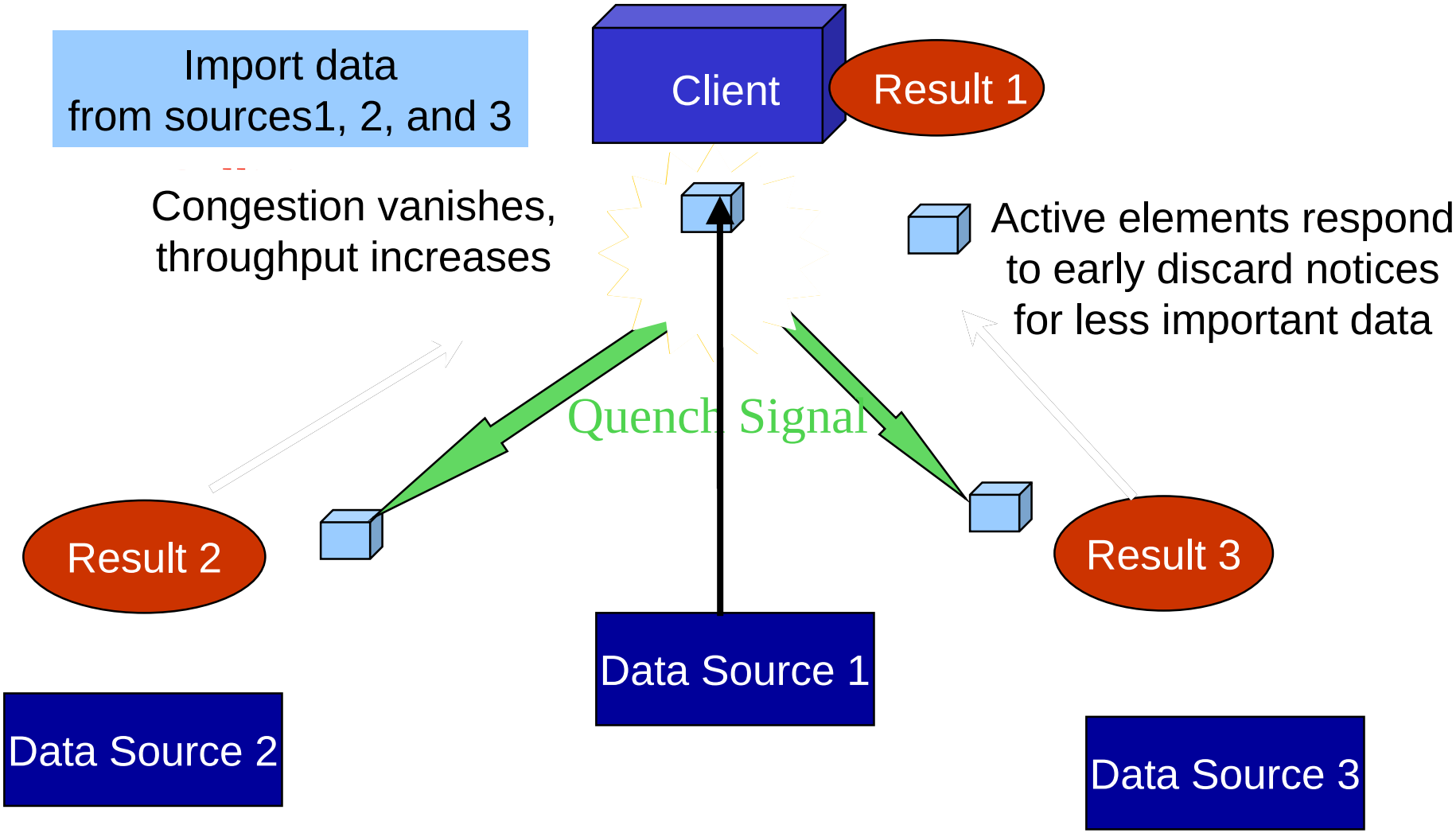
- Support new network services
- Easily create Virtual Private Networks with security
- Move mobile connection state through network seamlessly
- Add adaptive transcoding to different network link processors

IMPACTS OF THE ACTIVE APPROACH

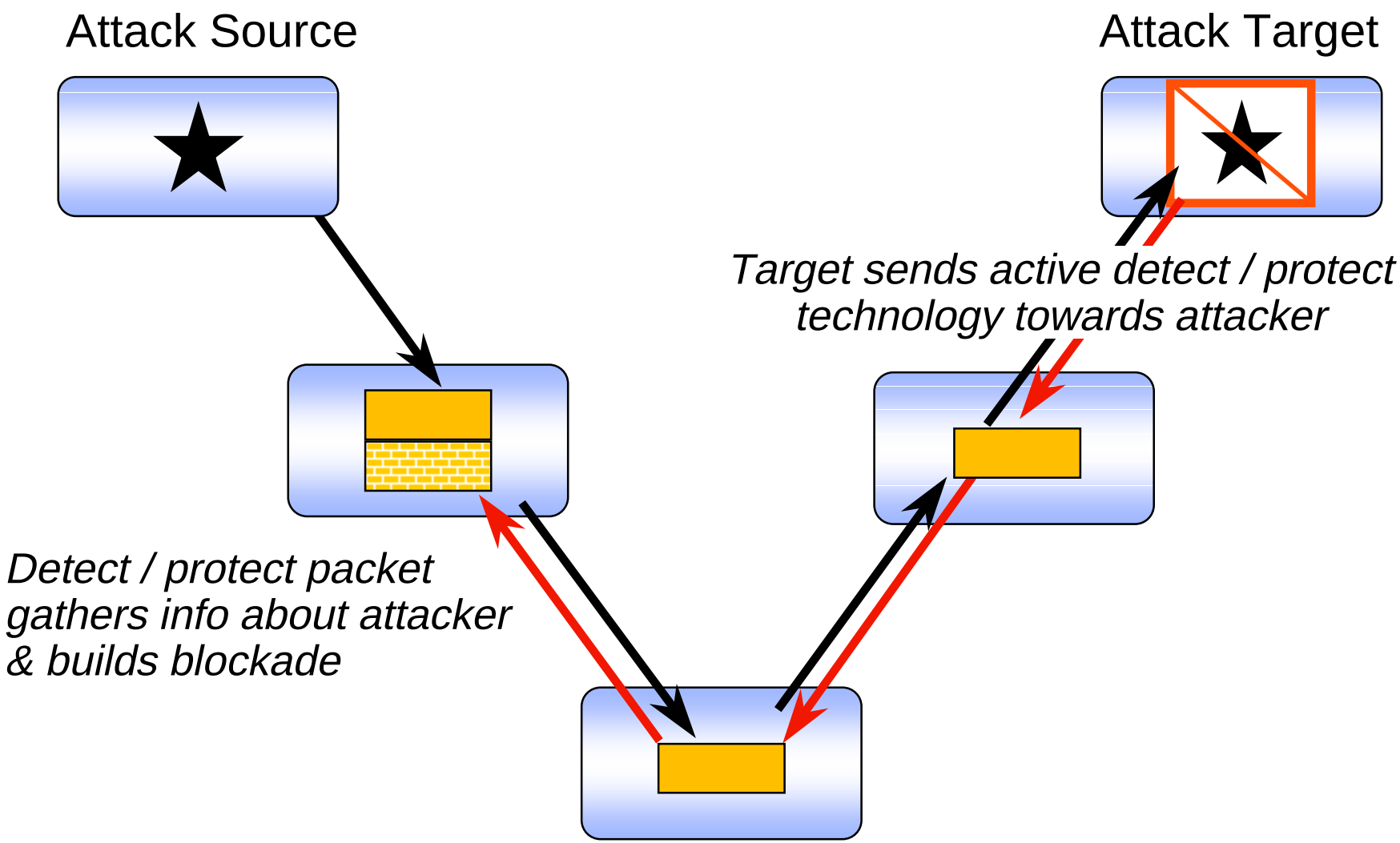


Network infrastructure that can instantly be tailored to mission requirements

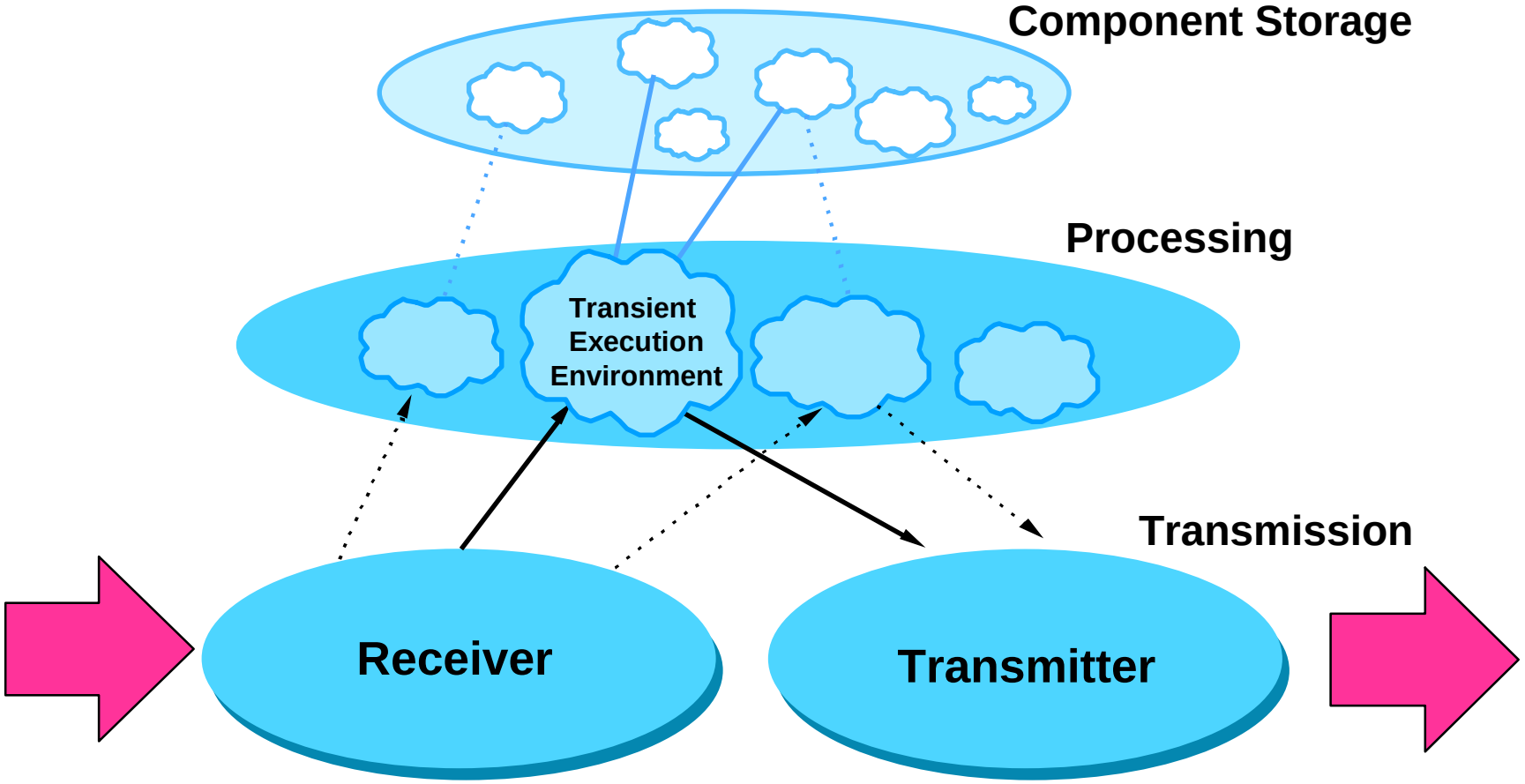
PRUNING / CANCELING PARALLEL QUERIES



NETWORK ATTACK TRACEBACK

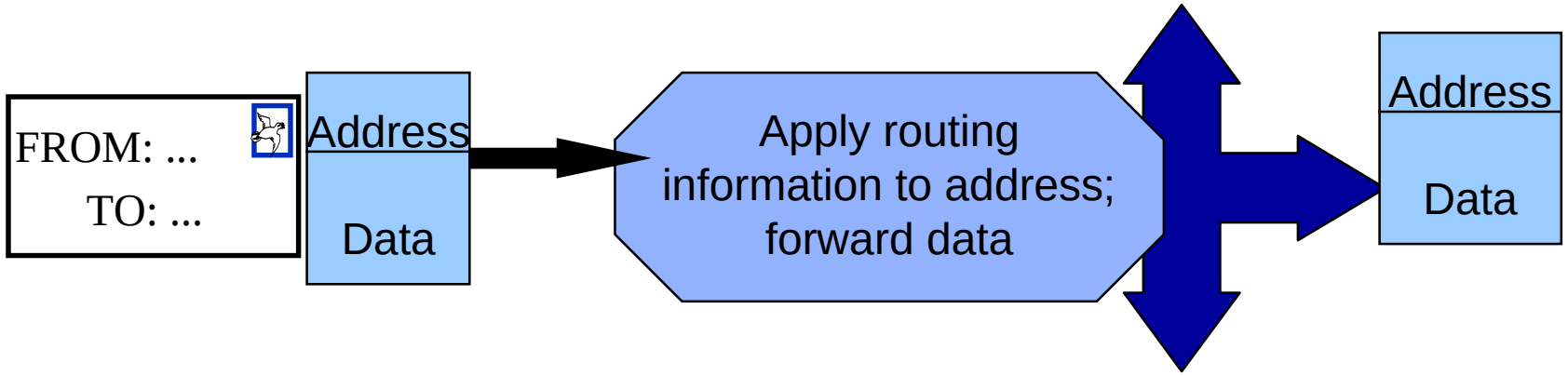


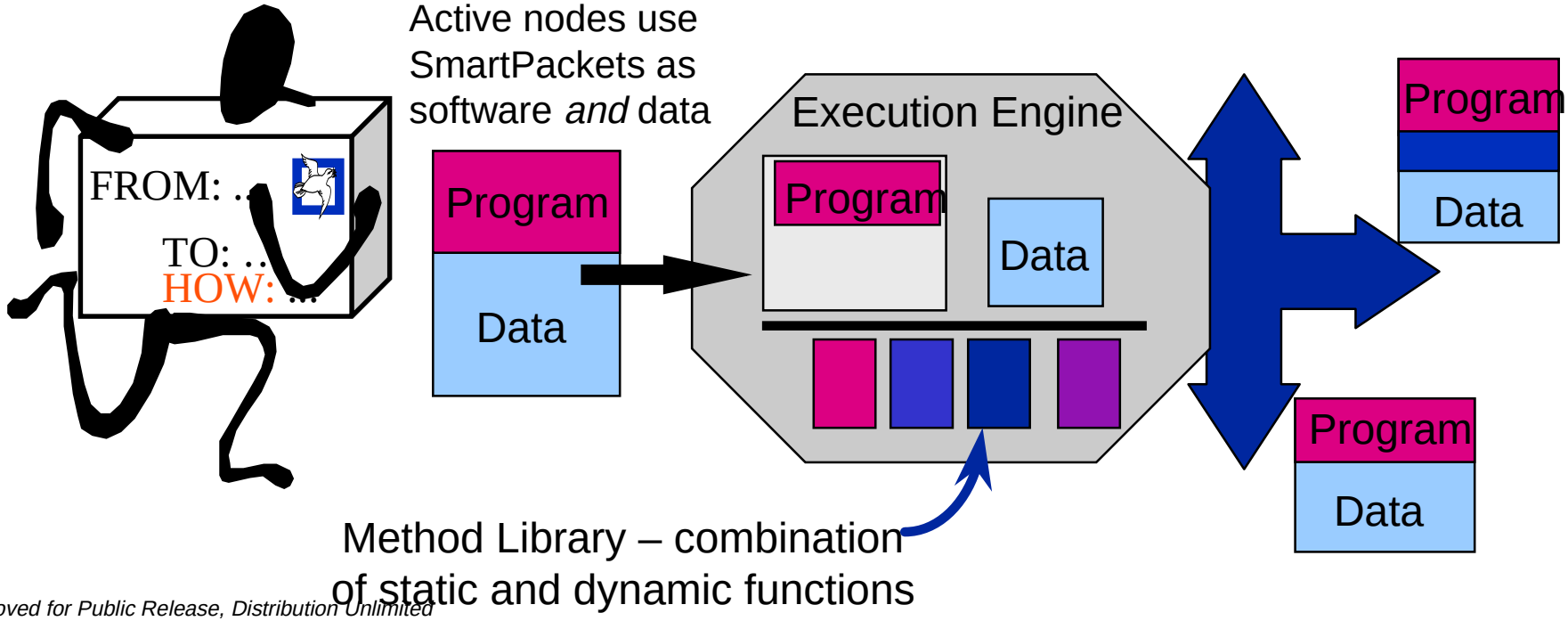
ACTIVE NODE ORGANIZATION



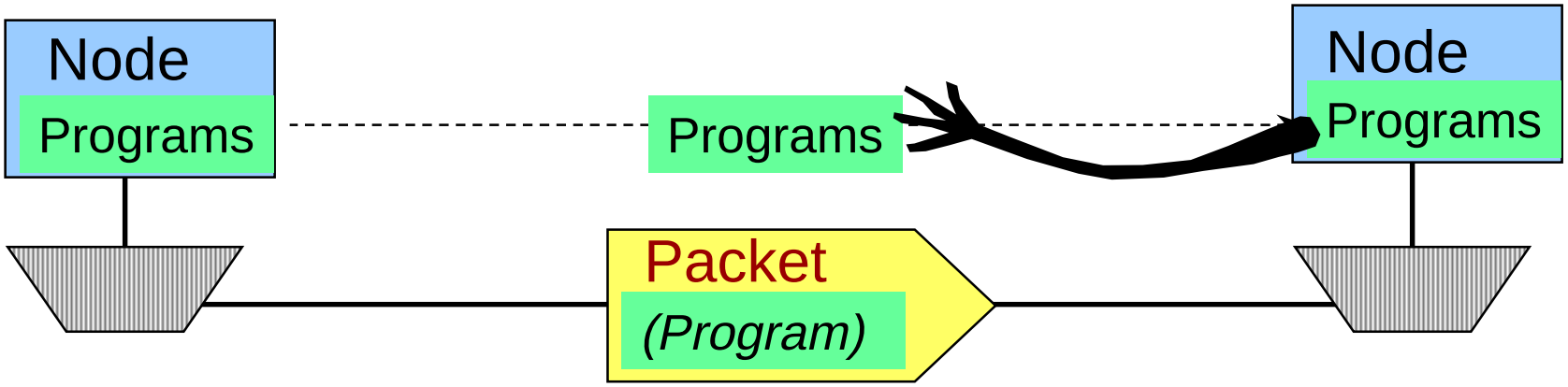
SMART PACKETS AT DUMB NODES

Static Packets: Network elements constrained to simple functions





MEETING THE PERFORMANCE CHALLENGES



Strategies being investigated:

- **Always carry program (node is empty)**
- **Program is "dropped" / cached at node**
- **Program is always "pulled" from repository**
- **Program is always there (somebody else's problem)**

NETWORK NODES HAVE NEW FUNCTIONS

Enables revolutionary changes:

- **Lets users define the protocols, providing**
  - Special signal transcoding, data fusion, quick discard of useless traffic, forward error correction, adaptive coding
- **Integrity protection of the network**
  - Assures basic delivery services
  - Controls resource consumption
  - Authenticates its own updates
- **Code distribution**
  - Programs can “live” along data paths
  - Flexible persistence strategies

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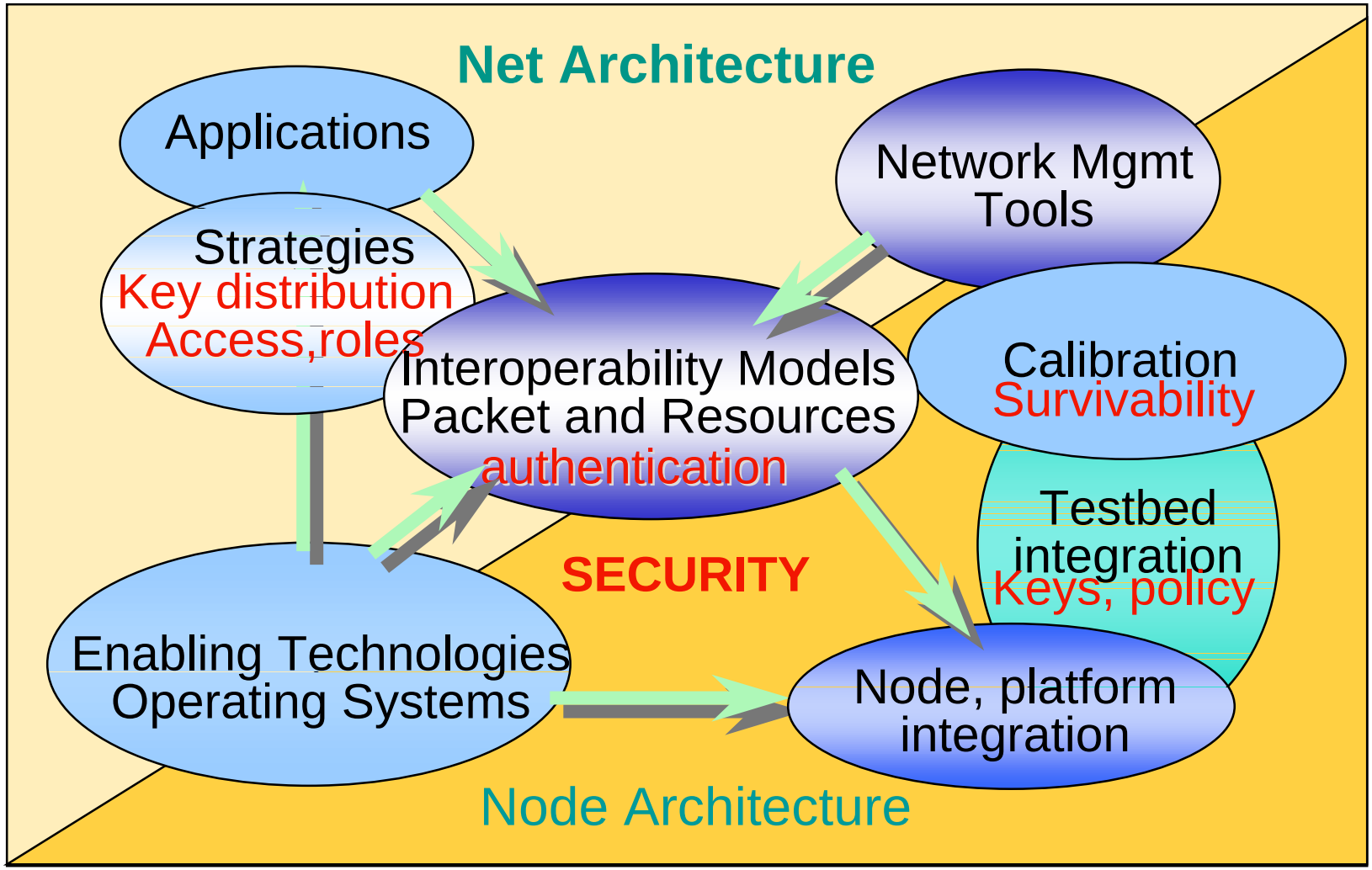
THE ACTIVE NETWORK ARCHITECTURAL ELEMENTS

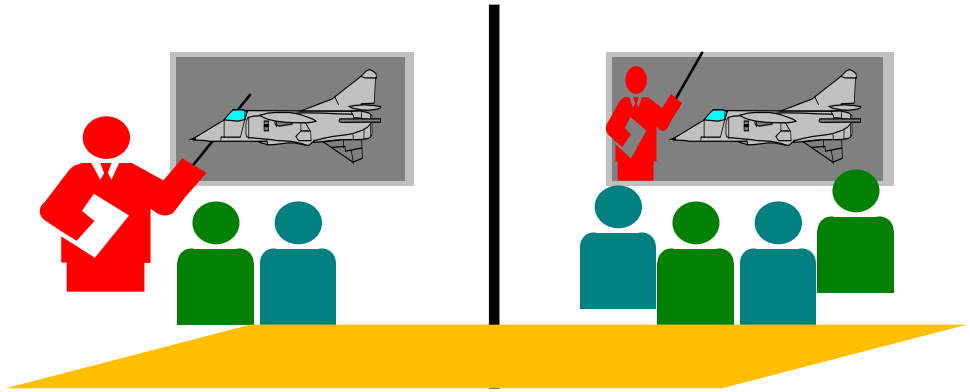


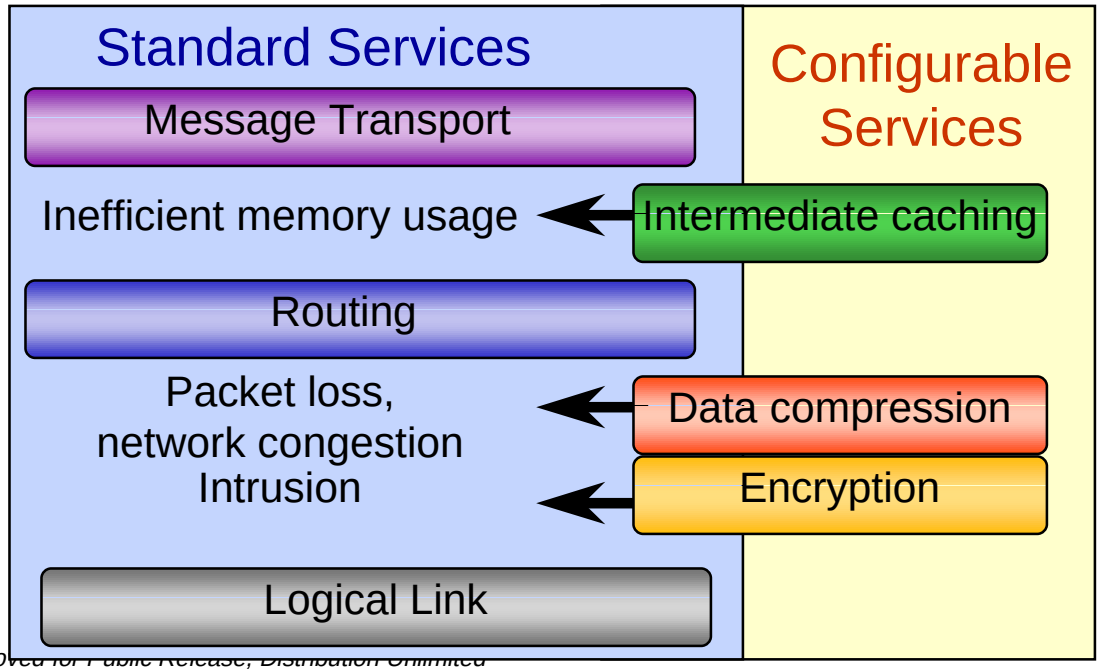
Security permeates architecture

Challenge Application

TELECONFERENCING IMPROVEMENTS DURING LIVE SESSIONS

Applications Use Network Services





- Active networks can **counter anomalies during live sessions** by introducing improvements directly into the underlying network elements
- The enhancements affect the intermediate processing nodes and target the physical **elements closest** to the problem
  - Users see immediate qualitative improvements in teleconferencing session – clearer audio, smoother video
  - Stronger security assurances

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WHAT THE INTERNET CAN AND ACTIVE NET WILL DO

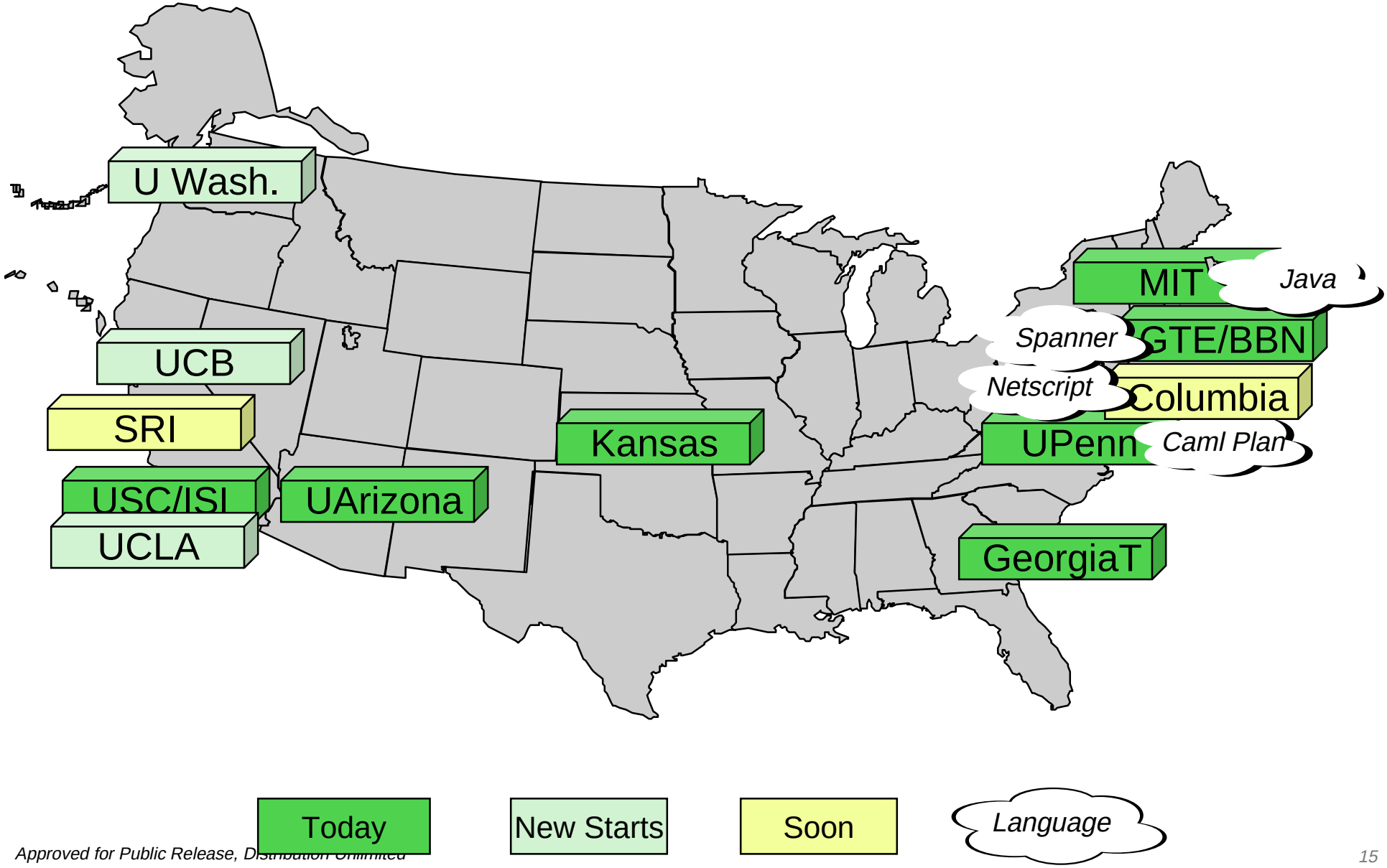
We Can:

- Support new, emerging applications
- Add limited security layers, i.e. firewalls
- Pretend that mobile hosts are static
- Multicast to similar end-user equipment

We WILL:

- Support new network services
  - Increase address space
- Painless VPN's
  - And additional security services
- Move mobile connection state through network seamlessly
- Add adaptive transcoding to different network link processors

ACTIVE NETS TESTBED TODAY: THE ABONE



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GOALS

- **Quantifiable Improvement in Network Services**
  - Audio/video synchronization and full-rate video over multicast
  - Fewer retransmitted packets, 100% increase in useful data rate to end applications
- **Architecture Creates Solutions to Future DoD Needs**
  - e.g., “addressless” networks, resource directed communication
- **Fault-Tolerance Mechanisms Based in Network**
- **Multi-Tiered Mobile Security**
  - Authentication forms basis for dynamic access control
  - Separate traffic and administrative functions based on types and policy

TRADING COMPUTATION FOR BANDWIDTH, *Actively*

Large Data Stream Reduced to Small One
at Nearest Capable Network Point

Mbps

Active Network Switch/Router

Programmable Packet Engine

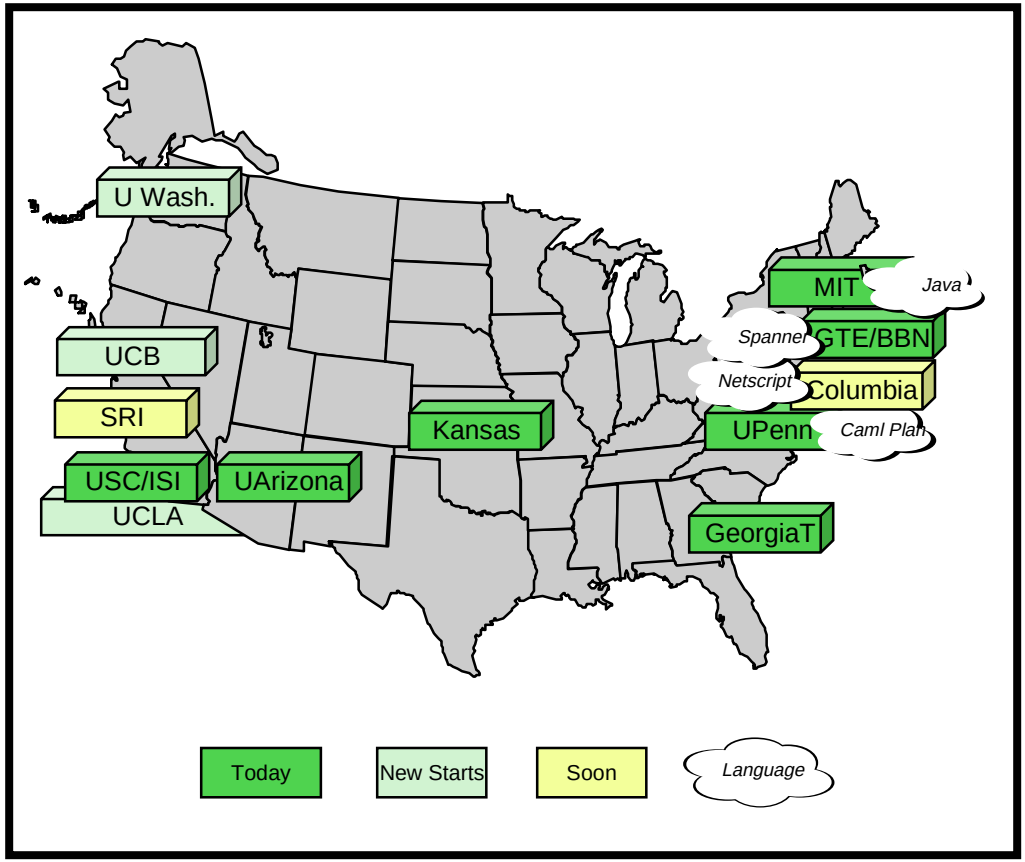
Mobile Conversion Software

Conversion Method Delivered As SmartPacket Stream

Kbps

Low Bandwidth Device
(embedded or handheld)

INITIAL INTEROPERABILITY GENERATES NEW IDEAS



New Ideas

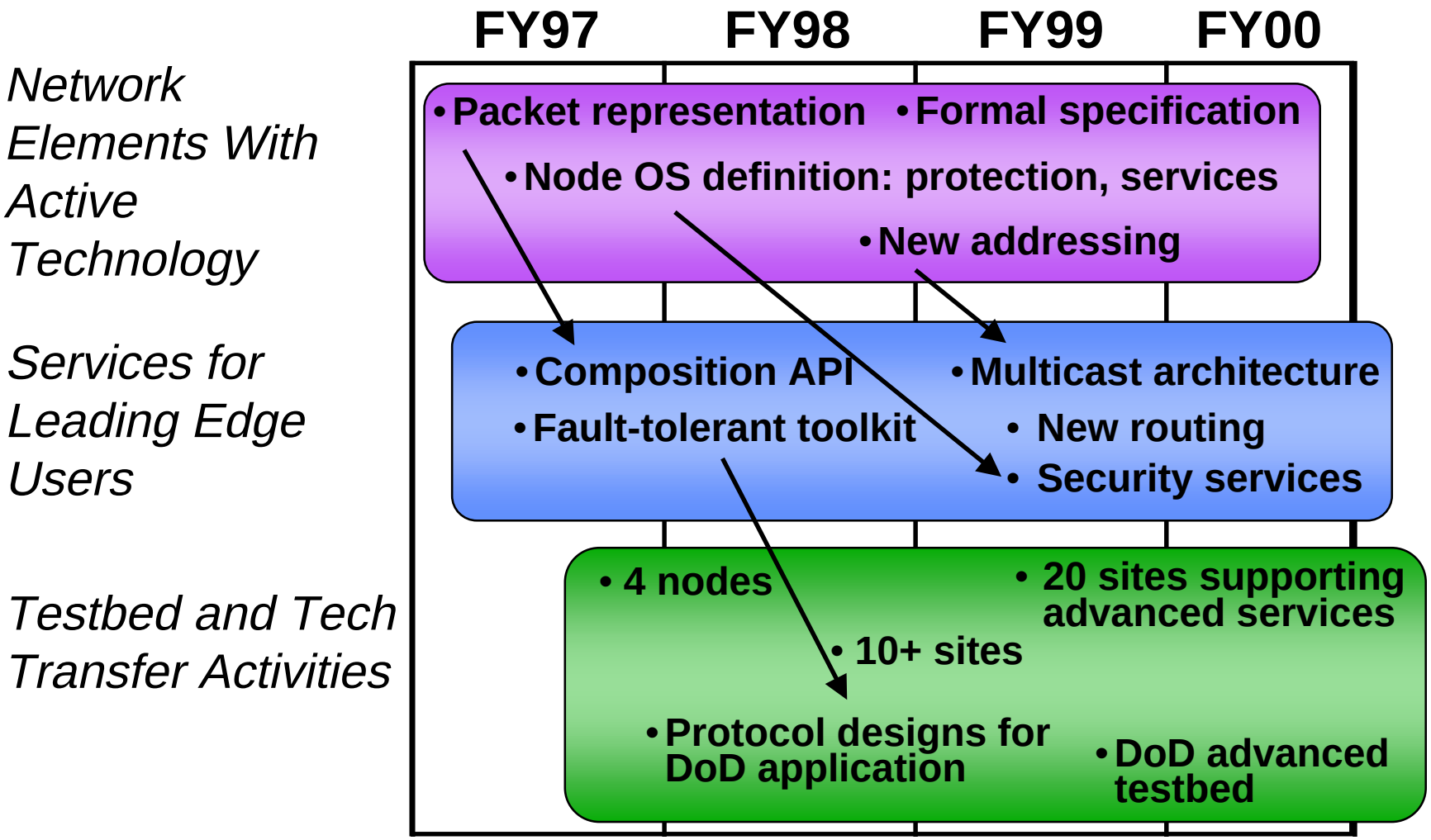
- Auctions on the net
- Security analysis carried out in parallel with code mobility
- Active networks matching legacy speeds
- Active sensor nets
- Lightweight virtual private networks
- Proxies-on-demand

ACTIVE NETWORKS – NUTSHELL SUMMARY

- **"Smart" messages instead of packets**
  - Carry code executed inside the network switches / routers
  - Routers are "breadboards"
- **Carriers and vendors can offer new services**
  - In-network storage: terabytes for rent
  - User-tailored link services (code for lease)
  - Quick deployment for network management services
- **Continuing evolution path**
  - Network is the platform for constant innovation
  - Stability of service --- old and new services co-exist

circuits → packets → Smartpackets

ROAD MAP


FY97
FY98
FY99
FY00
Network Elements With Active Technology
Services for Leading Edge Users
Testbed and Tech Transfer Activities
• Packet representation
• Formal specification
• Node OS definition: protection, services
• New addressing
• Composition API
• Fault-tolerant toolkit
• Multicast architecture
• New routing
• Security services
• 4 nodes
• 10+ sites
• 20 sites supporting advanced services
• Protocol designs for DoD application
• DoD advanced testbed