



Telcordia  
Technologies

*Performance from Experience*



# Agent Technology for Network Management

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# Outline

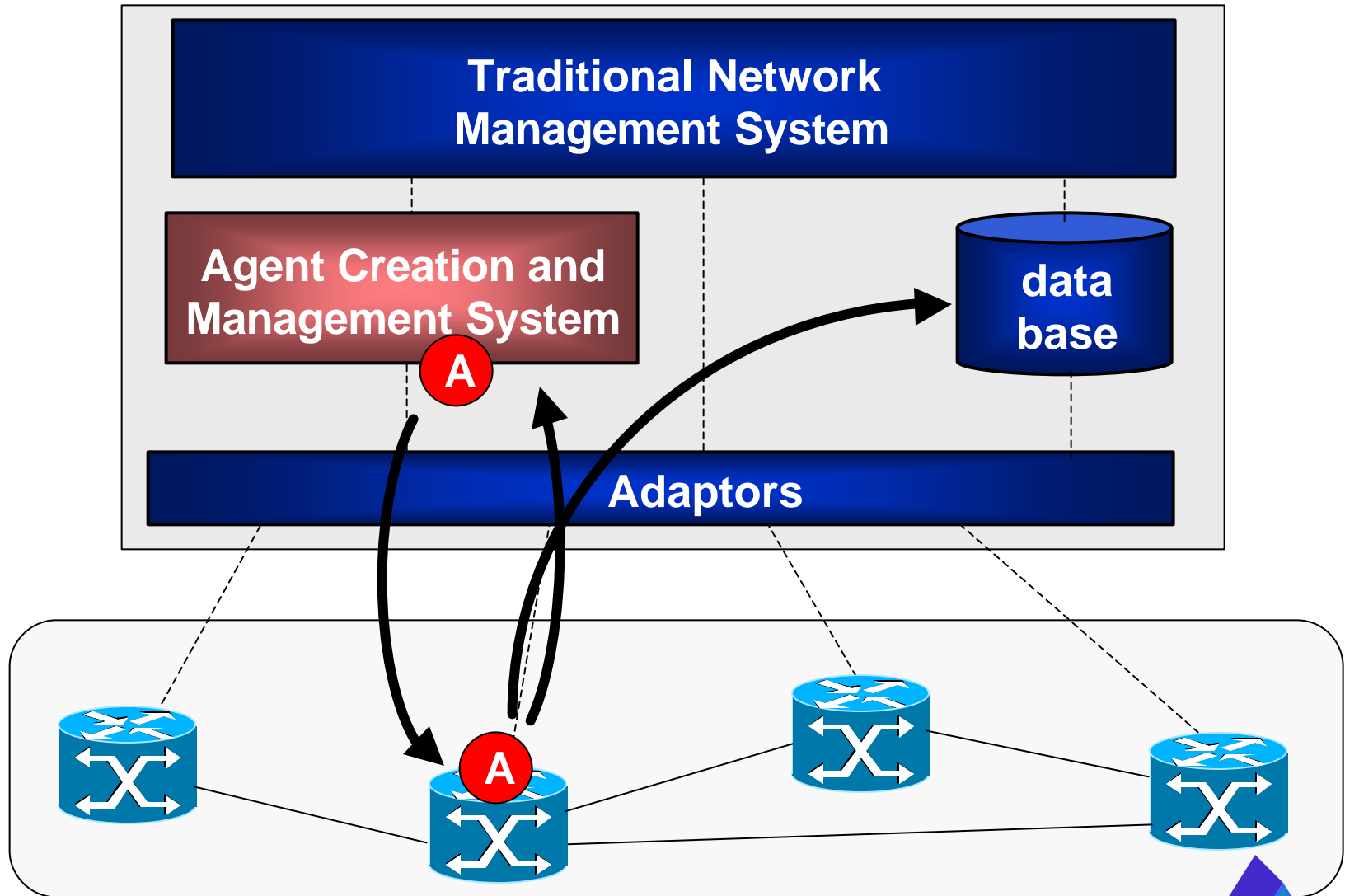
- Some mobile agent basics
- Motivation for their use in network management
- Specific examples of what mobile agents may be able to do for us
- Key research issues: major questions and challenges in implementing agent-based network management

# What is a Mobile Agent (MA)?

## A Loose, Operational Definition

- A software object that can be dynamically replicated, dispatched to and retracted from network elements
  - not hard-coded into network-element software
- Its goals are established by the agent management system; it makes decisions and takes actions autonomously in pursuit of these goals
  - can obtain its own thread of control on host network element
- The attributes of the agent and the agent management system vary with the application

# Mobile Agent Illustration



# Prior Research: MAs for Network Management

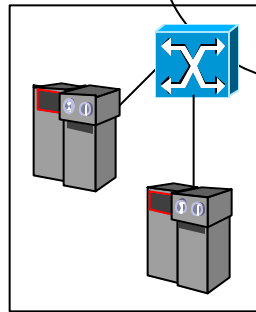
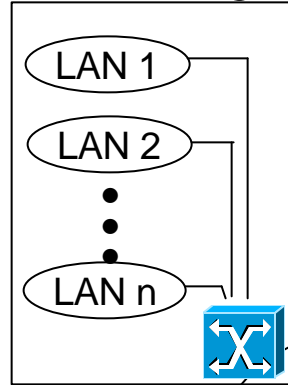
- Many papers, some dating back >10 years
- Papers have offered much conjecture on the benefits of MAs for network management, principally:
  - reduction in data traffic related to network management
  - better scalability resulting from a more-distributed network management paradigm
- The claims are unsubstantiated and remain dubious
- The REAL value may be in providing carriers with greater flexibility in network-management capabilities
  - filling gaps in conventional management functionality
  - facilitating speedy support of new services and features

# Our Research Goals

- Demonstrate MA-based network management functionality in a testbed environment
- Develop a detailed understanding of what it takes to implement a MA infrastructure
- Assess the relative value of the mobile-agent approach compared with conventional methods
  - Compare the “gain” with the “pain” of an MA-based system
- Draw conclusions on whether, how and where carriers are likely to use MAs
- Difficult to do in general terms; use specific network examples and case studies to gain insights

# Network Example - Metro Ethernet

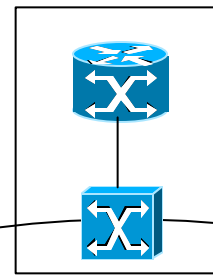
Multi-tenant  
Building



Data Storage  
Facility

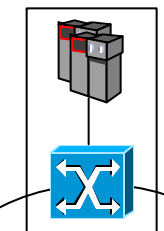
Access  
Ring

ISP Point  
of Presence



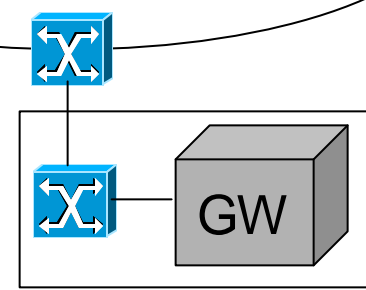
 GbE L2  
Switch

Web Hoster



Access  
Ring

Metro/Regional Network  
(GbE/10GbE Core)



VoIP  
Gateway

# Why Focus on Ethernet?

- The low cost and IP-friendly nature of Ethernet hardware make it attractive to carriers
  - Major Government agencies are planning large-scale Ethernet deployments
  - Pacific Rim countries buying thousands of Ethernet switches for Metro-area applications
  - Domestic carriers have issued requirements for Metro Ethernet networks (both hardware and network management)
  - ISPs increasingly peering with each other at Layer 2
- However, managing large-scale Ethernet networks is an unsolved problem and presents many challenges

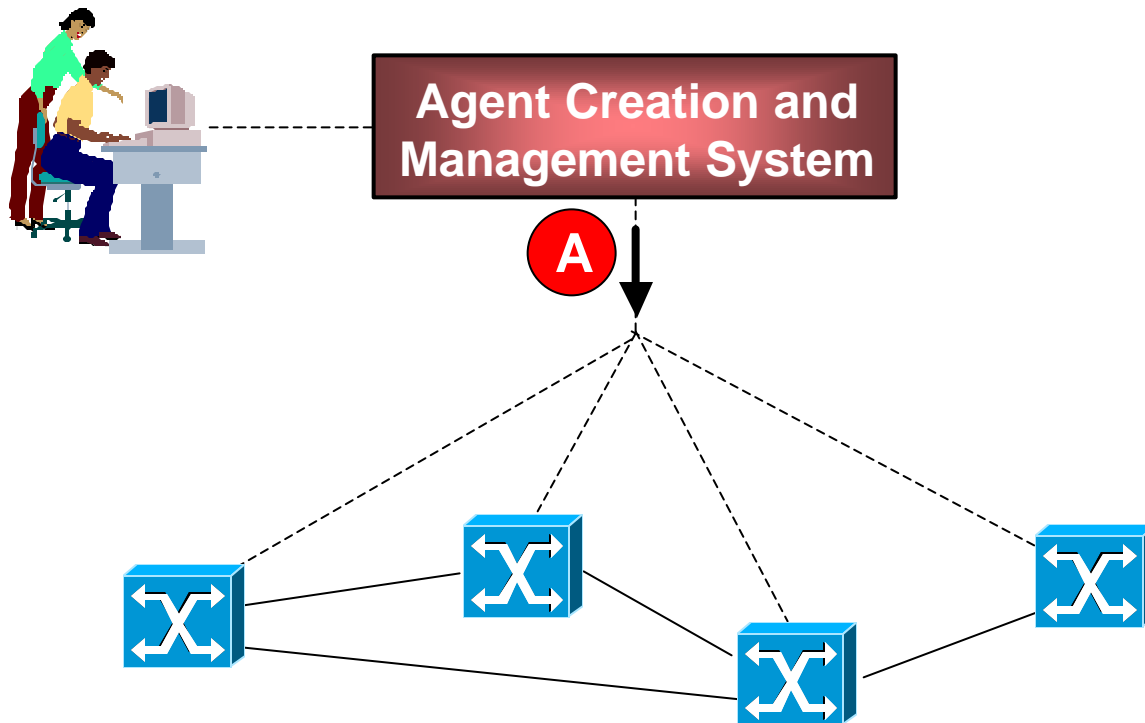
# Metro Ethernet Management Challenges

- Ethernet's roots are in enterprise networks
  - carrier-grade network management capabilities are lacking
  - hardware continues to evolve to meet carriers' needs
- Ethernet switch configuration (e.g., via CLI) is labor-intensive, slow and error-prone
- Ethernet is connectionless
  - carrier cannot directly control traffic routes, similar to conventional IP networks without MPLS
  - Ethernet's reaction to network faults can be unpredictable

*Ethernet hardware is economical, but inadequate NM capabilities have impeded large-scale carrier deployment*

# Example MA Applications in Metro Ethernet

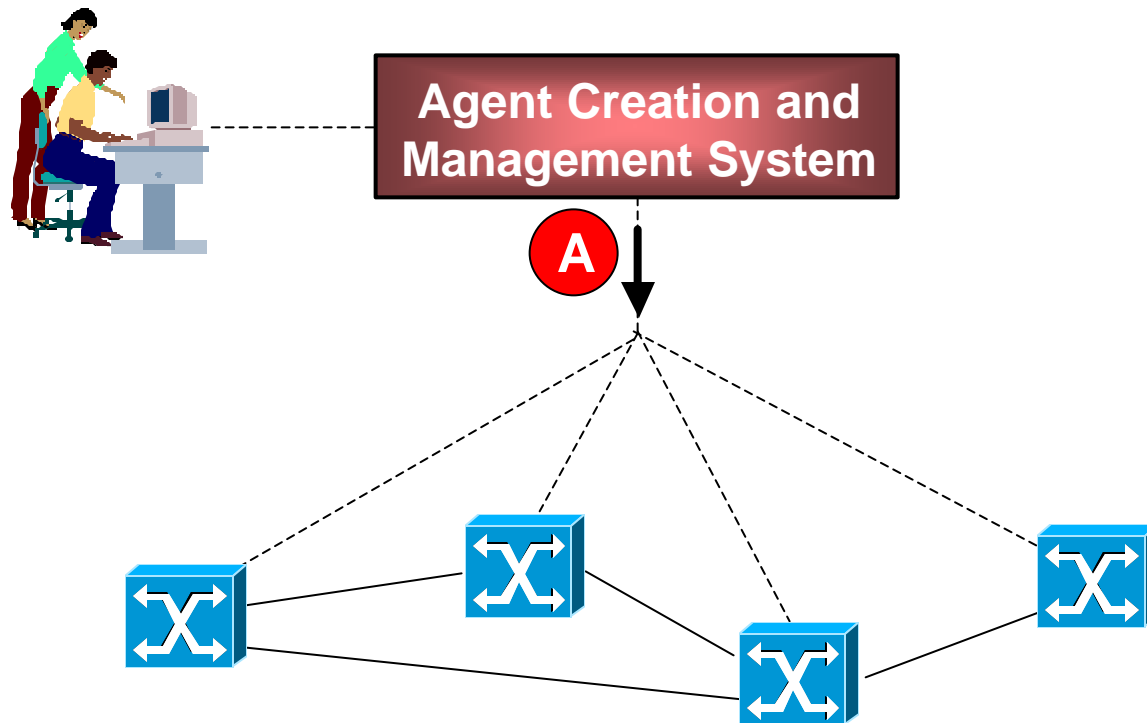
## Auto-Discovery



- Notify network management of changes to switch configuration....
- Discover and report all spanning tree routes...
- Discover and report all VLAN topologies...

# Example MA Applications in Metro Ethernet

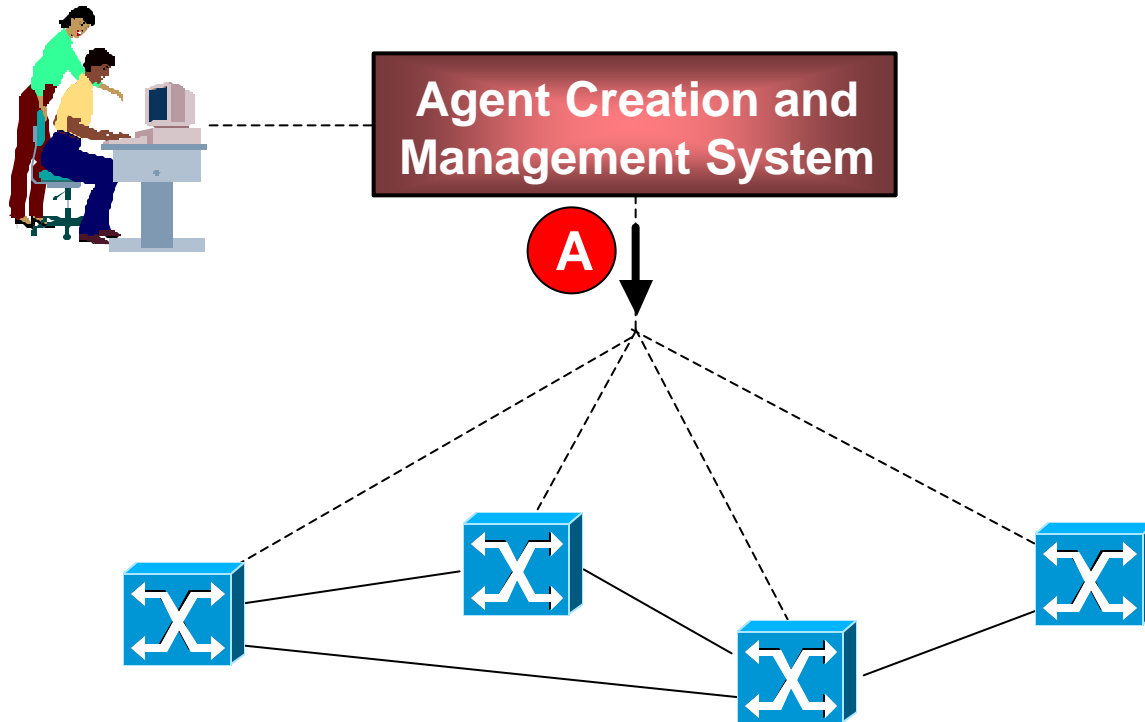
## VLAN Configuration



- Configure a VLAN with the following ingress/egress points and QoS parameters...
- Create a spanning tree for this VLAN with the following route...

# Example MA Applications in Metro Ethernet

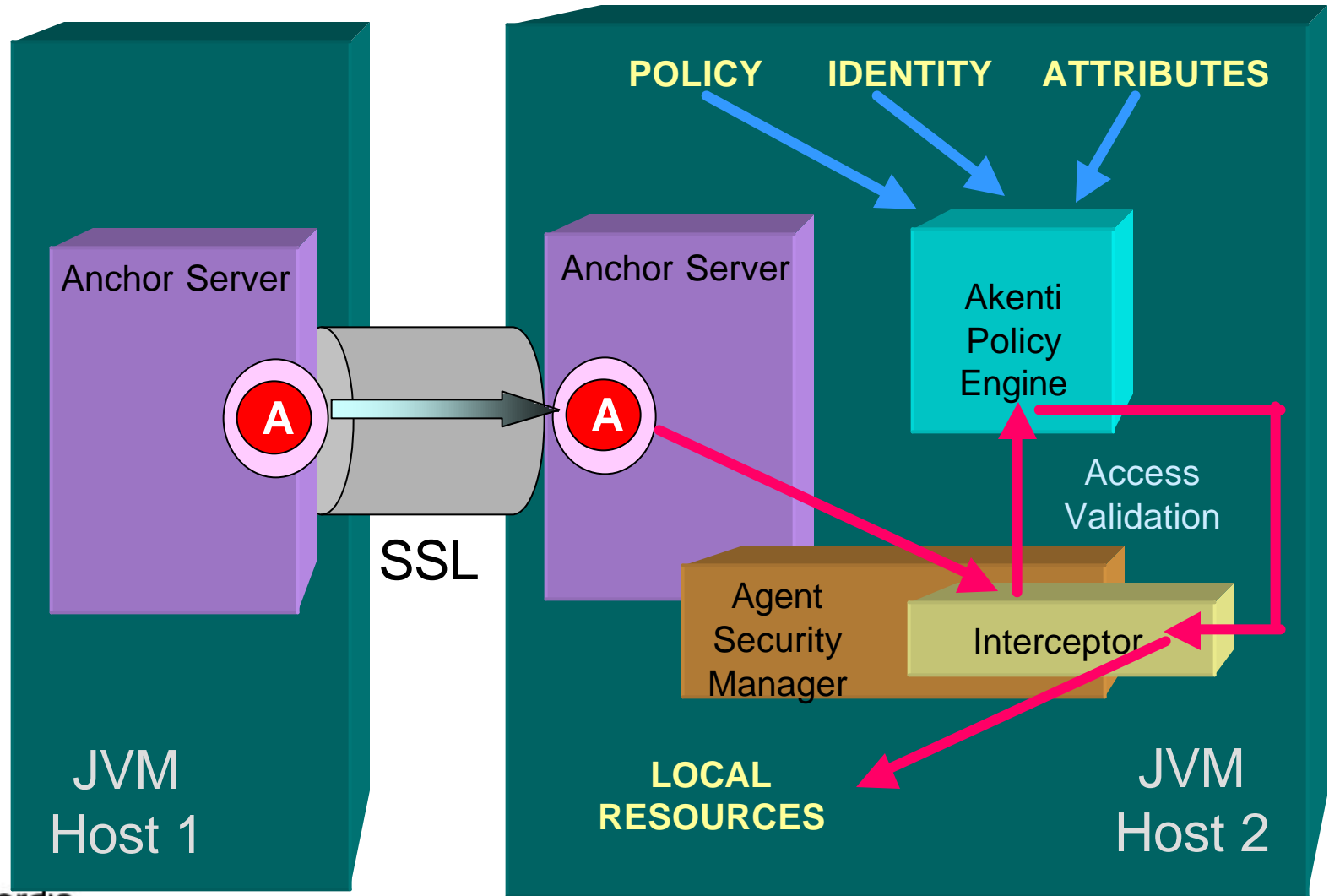
## Service Validation and SLA Management



- Verify the following configuration settings along the path of VLAN XYZ, and report discrepancies
- Collect and report jitter and packet-loss statistics on VLAN XYZ

# Example Platform: Anchor Toolkit/Akenti

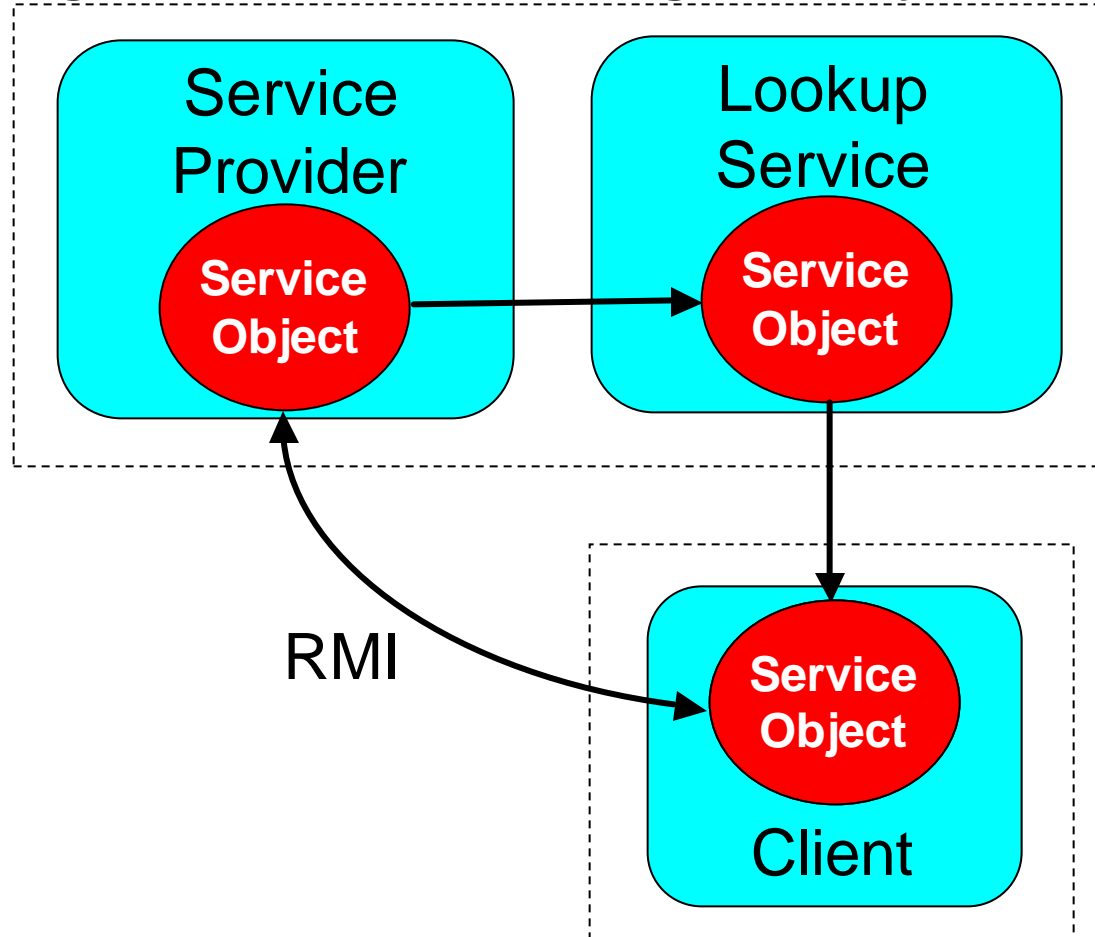
Lawrence Berkeley Labs



# Example Platform: Jini™

Sun Microsystems

## Agent Creation and Management System



## Managed Network Element

# Other Agent Systems - A Sampling

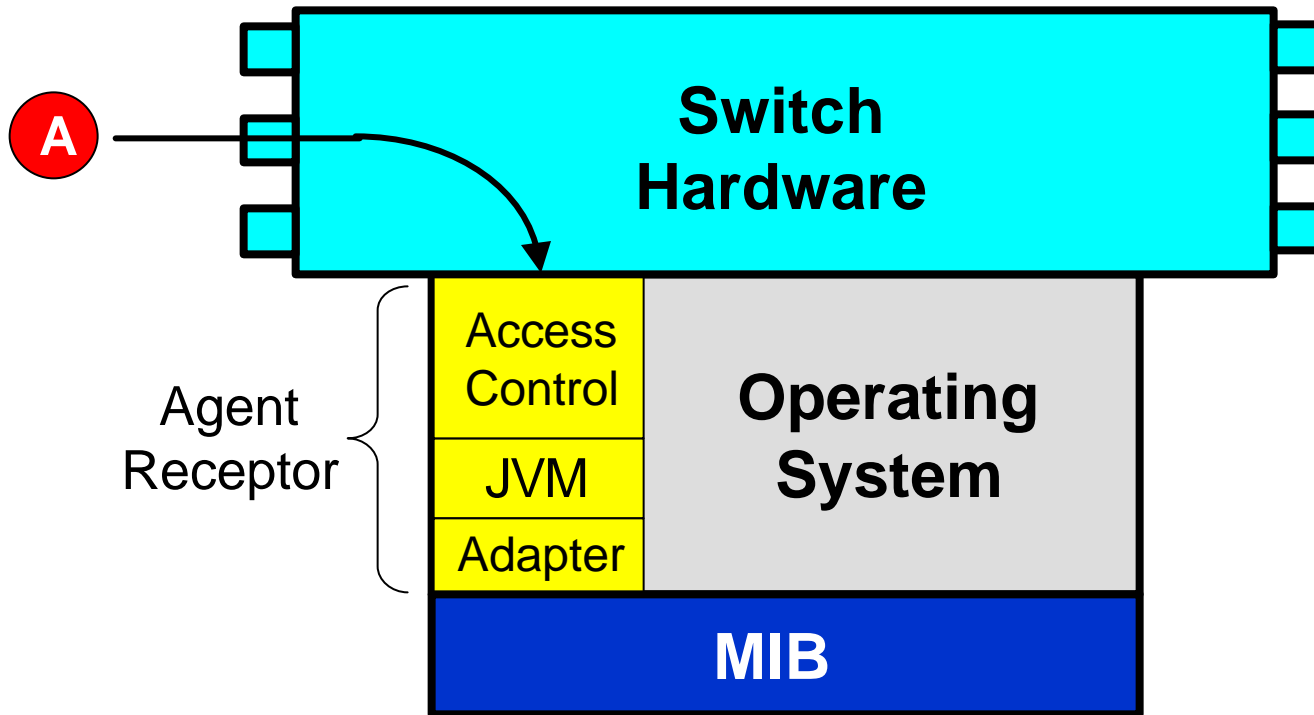
- Commercial
  - Aglets from IBM
  - AgentBuilder from IntelliOne Technologies
  - GrassHopper from IKV++ Technologies
- Academic & Research
  - D'Agents from Dartmouth University
  - Mobile Code Toolkit from Carleton University
  - Hive from MIT
  - JATLite from Stanford University
  - JADE from CSELT, Italy
  - FarGo from Isreal Institute of Technology
  - Ajanta from Univ. of Minnesota
  - MAgNET from UCSB

# Key Questions to Address

- Will network elements accommodate MAs easily?
  - code loading, Java Virtual Machines (JVMs)
- How does one maintain control over MA actions?
  - limiting authority and access to network-element resources
  - authentication of MAs
- How many MAs are needed in a network?
  - should they replicate themselves, or should we use a “centralized create, dispatch and retrieve” model?
- How mobile do the MAs have to be?
  - single-hop vs. multi-hop/roaming capability
- Do MAs need to communicate with one another?
- How intelligent can/should we make the MAs?

# Accommodating MAs

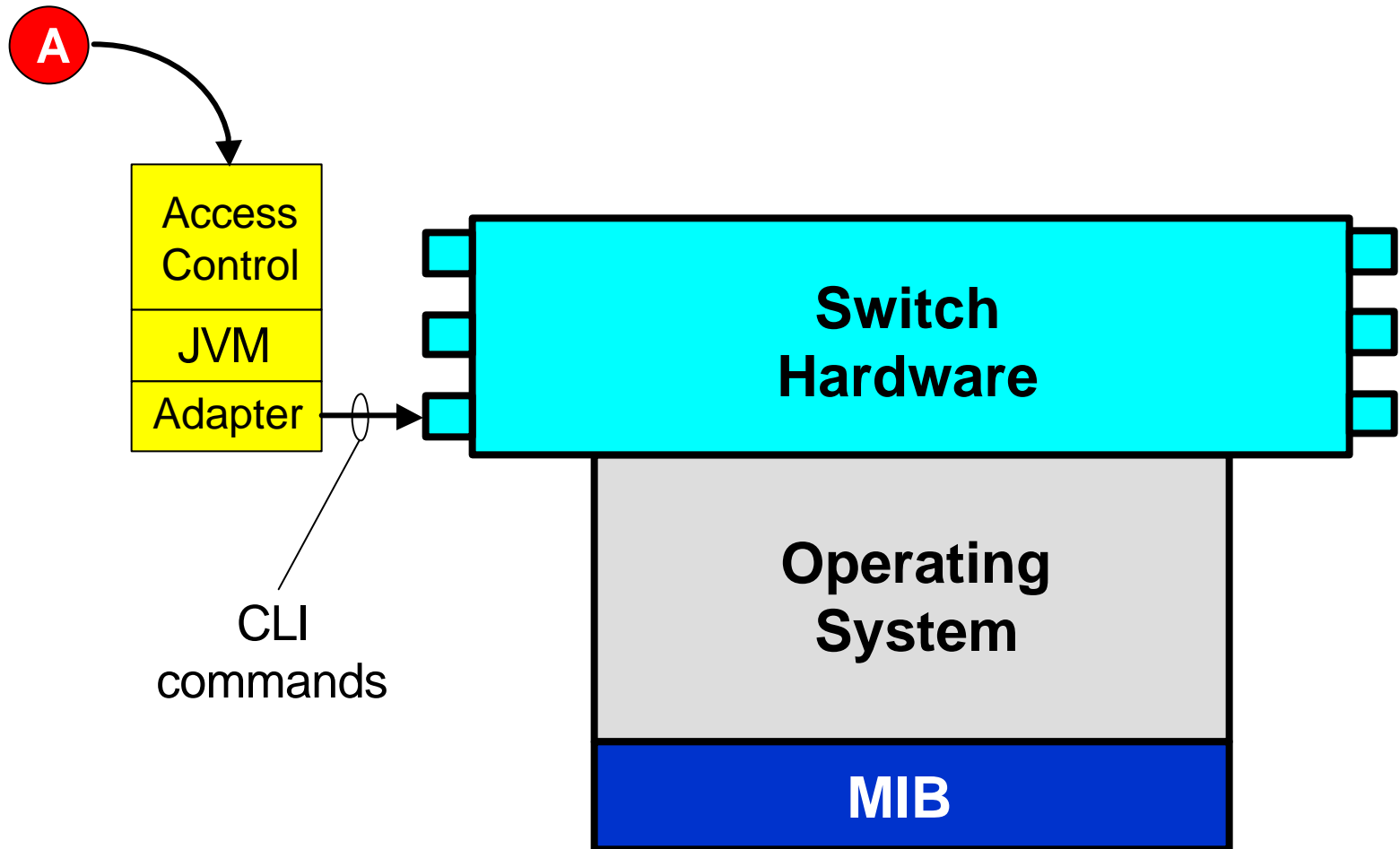
## Direct Support on Switch



MIB = Management Information Base

# Accommodating MAs

## Use of External Receptor



# Security

- Little work done on security of MA systems
  - Important issues are:
    - Protect Host from an Agent
      - Authenticate an incoming agent
      - Verify security of the information it carries
      - With active agents, agent is probably running before you can authenticate. How do we deal with this?
    - Protect Agent from the Host
      - How can the agent trust the host?
      - No easy solutions for this
    - Protect agents from one another
      - This is very difficult
    - Limit and eventually terminate the agent's power to act on behalf of the network management system

# Security - continued

- Most proposals use Java security apparatus
  - Addresses only the rogue agent problem
    - Authenticate the agent
    - Limit its access to protected local resources
  - Does not solve other problems
- Some (Anchor/Akenti) enhance security provided by Java, principally:
  - Enforce security policies by using interceptors which override Java default mechanisms
  - Use secure encrypted communication between agent servers

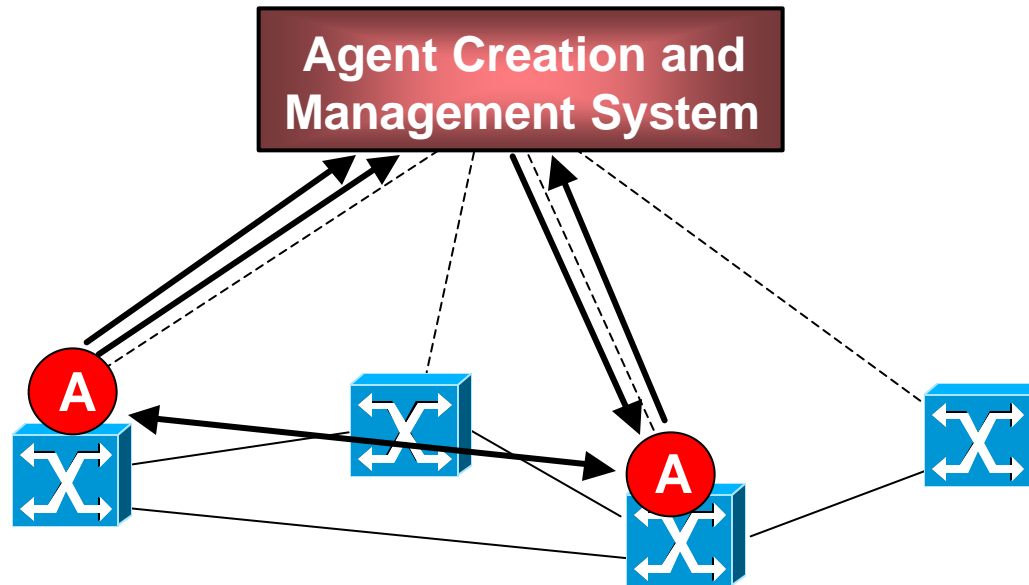
# Number, Mobility and Intelligence of MAs

*Example Task: Discover the topology of VLAN XYZ*

- Two extreme cases:
  1. a single MA hops around the network looking for XYZ
  2. separate MAs are dispatched to each machine to look for XYZ; information sent to centralized management system
- Case (1) requires a more-sophisticated agent that makes mobility decisions and carries its own data
- Case (2) requires only single-hop mobility and minimal agent intelligence
  - agents act as relatively simple probes while a highly shared management system does the processing
  - Jini-like model; minimizes demand on switch CPU

# Inter-Agent Communication

## Three Options



1. Agents communicate directly with each other
2. Agents communicate indirectly, through mail boxes or a proxy server
3. Agents communicate only with management system

# Observations

- One can envision many feasible combinations of MA attributes
  - the best combination may depend on the network management task to be performed
- Developing appropriate metrics may be one of the biggest challenges
  - how do we compare the relative merits of different MA implementations?
  - how do we know if the MA approach is better than conventional network management techniques?
  - can we develop metrics that accurately reflect what really matters to the network operator (e.g., complexity, cost)?