

PNNI: Routing in ATM Networks

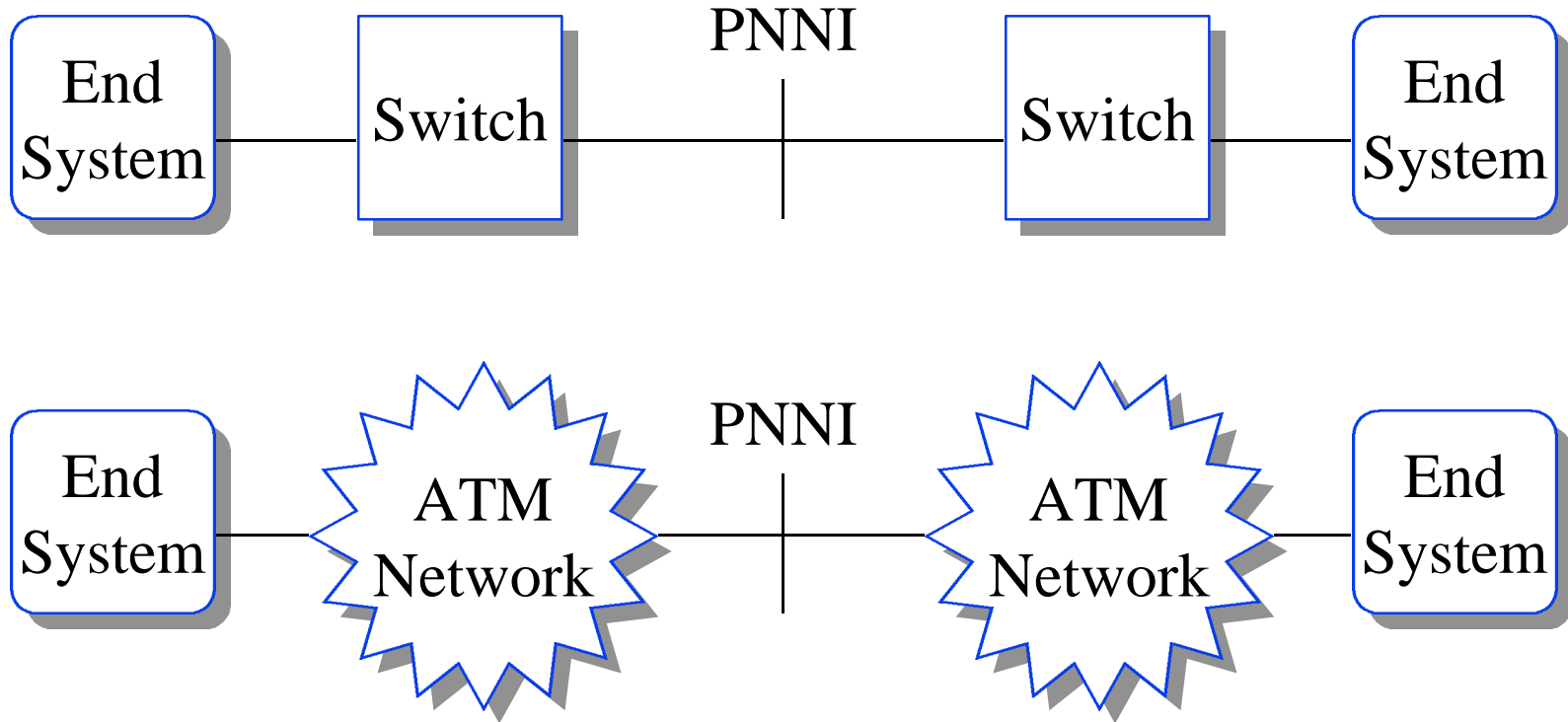
Raj Jain

**Raj Jain is now at
Washington University in Saint Louis
Jain@cse.wustl.edu
<http://www.cse.wustl.edu/~jain/>**



- q Distribution of topology information
- q Hierarchical groups
- q Source routing ↻ Designated Transit Lists
- q Crankback and Alternate routing
- q Addressing
- q Ref: "PNNI V1.0 Specification (Mar 1996)"

PNNI



- q Private Network-to-network Interface
- q Private Network Node Interface

Features of PNNI

- q Point-to-point and point-to-multipoint connections
- q Can treat a cloud as a single logical link
- q Multiple levels of hierarchy \Rightarrow Scalable for global networking.
- q Reroutes around failed components at connection setup
- q Automatic topological discovery \Rightarrow No manual input required.
- q Connection follows the same route as the setup message (associated signaling)
- q Uses: Cost, capacity, link constraints, propagation delay
- q Also uses: Cell delay, Cell delay variation, Current average load, Current peak load
- q Uses both link and node parameters
- q Supports transit carrier selection
- q Supports anycast

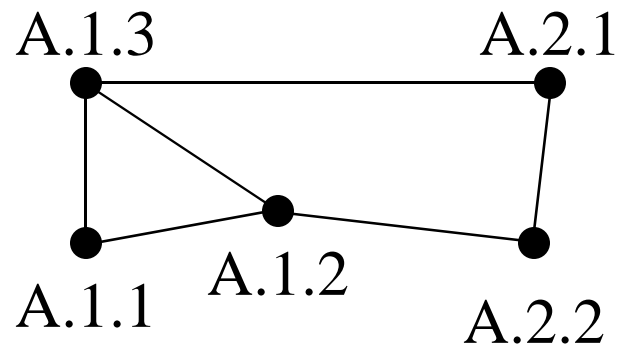
Addressing

- q Multiple formats.
- q All 20 Bytes long addresses.
- q Left-to-right hierarchical
- q Level boundaries can be put in any bit position
- q 13-byte prefix \Rightarrow 104 levels of hierarchy possible

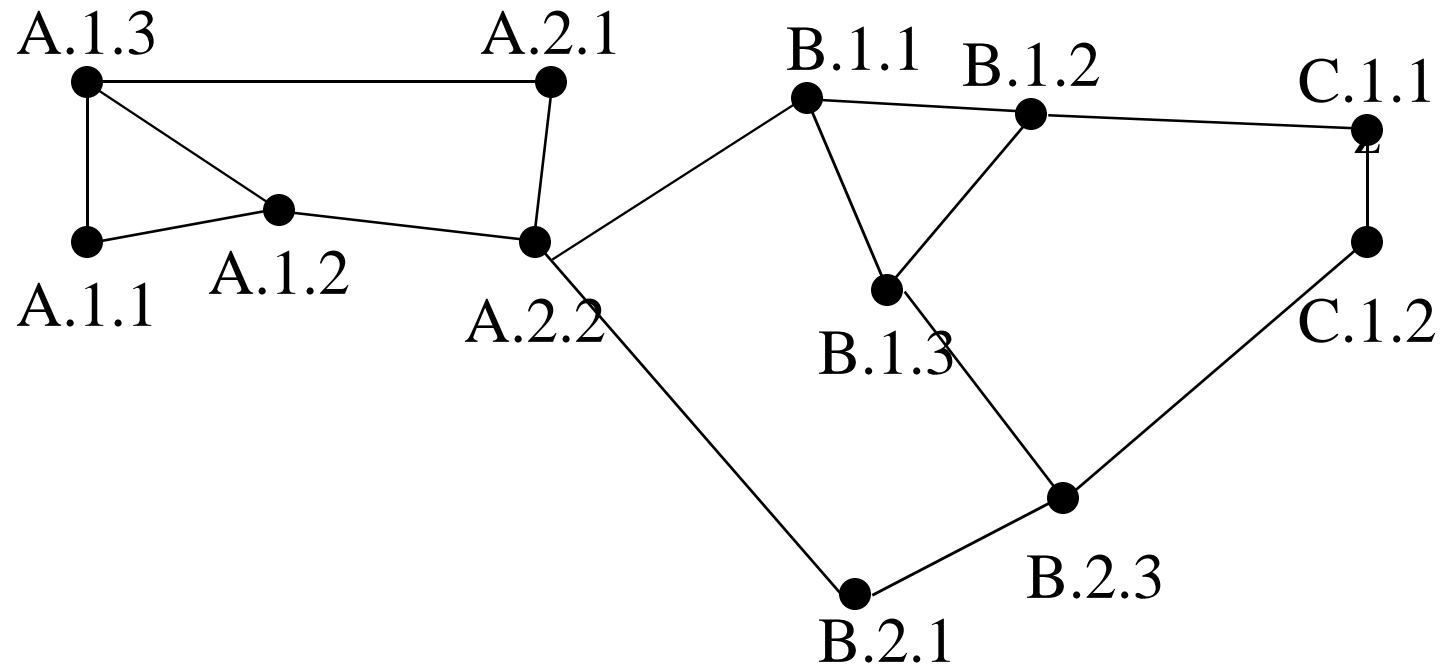


Link State Routing

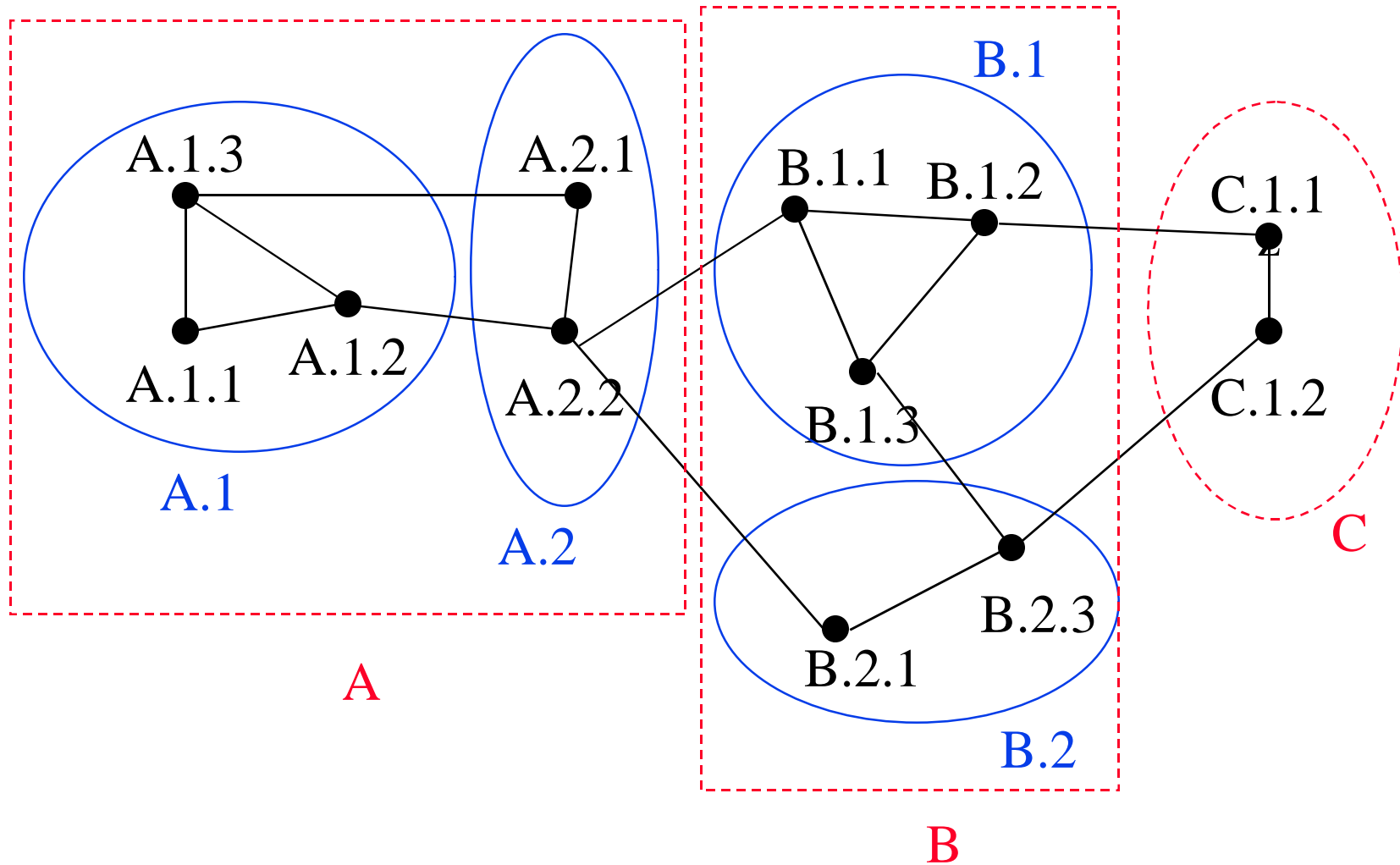
- q Each node sends “Hello” packets periodically and on state changes.
- q The packet contains state of all its links
- q The packet is flooded to all nodes in the network



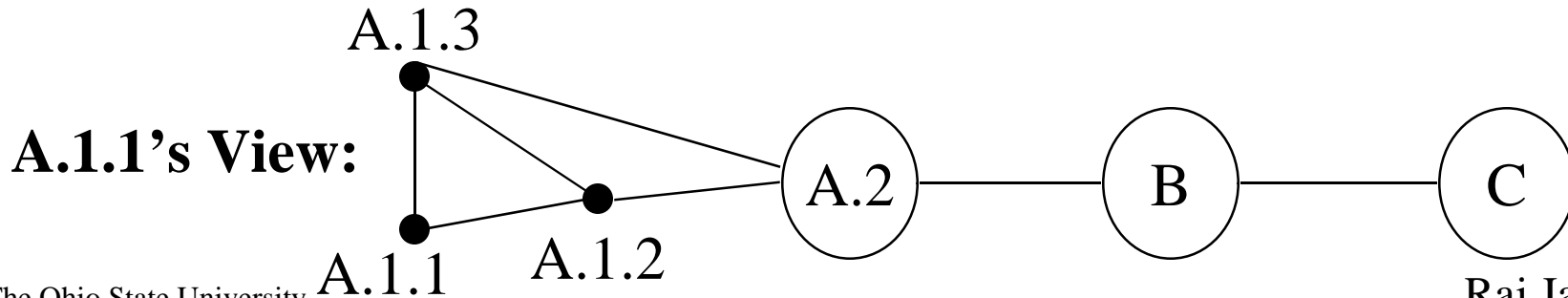
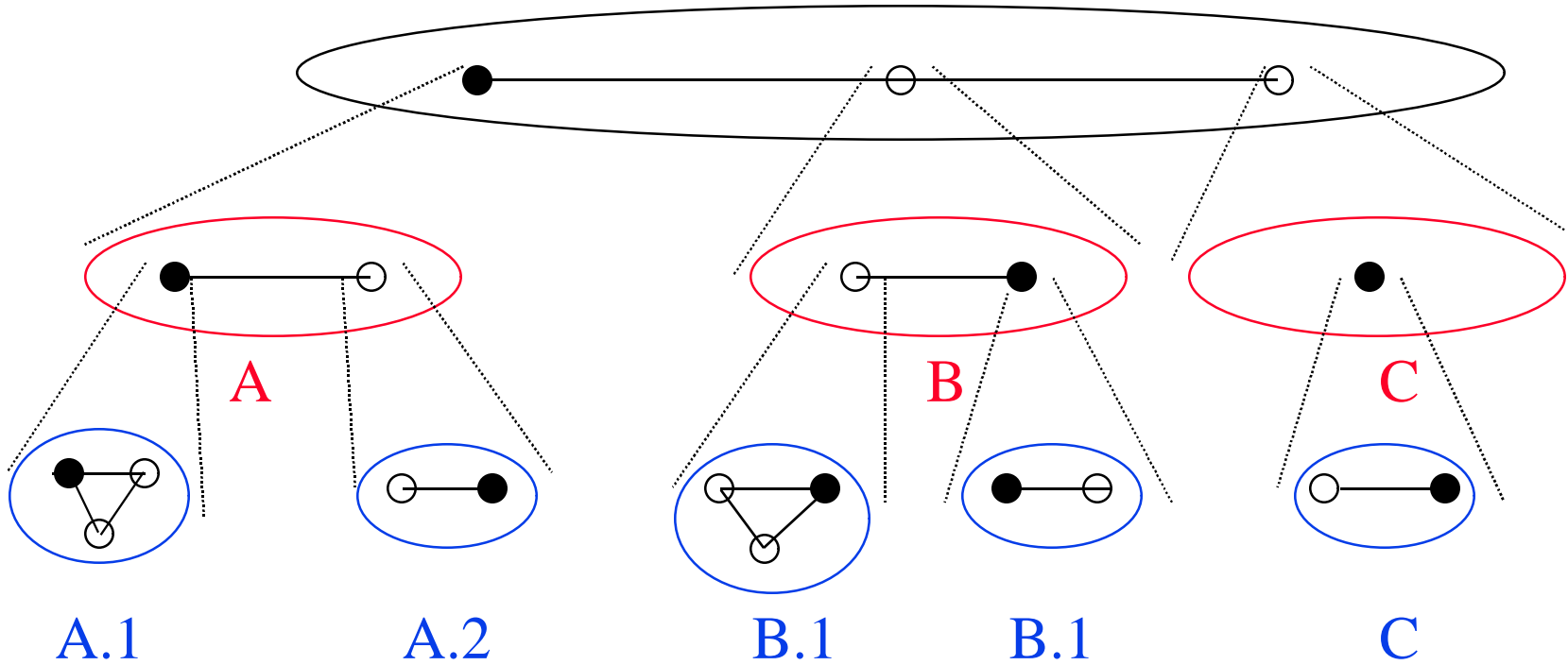
Very Large Networks



Hierarchical Layers



Hierarchical View



Terminology

- q Peer group: A group of nodes at the same hierarchy
- q Border node: one link crosses the boundary
- q Logical group node: Representation of a group as a single point
- q Logical node or Node: A physical node or a logical group node
- q Child node: Any node at the next lower hierarchy level
- q Parent node: Logical group node at the next higher hierarchy level
- q Logical links: links between logical nodes

Terminology (Cont)

- q Peer group leader (PGL):
Represents a group at the next higher level.
Node with the highest "leadership priority" and highest ATM address is elected as a leader.
Continuous process \Rightarrow Leader may change any time.
- q PGL acts as a logical group node.
Uses same ATM address with a different selector value.
- q Peer group ID: Address prefixes up to 13 bytes

Topology State Information

- q Metric: Added along the path, e.g., delay
- q Attribute: Considered individually on each element.
 - q Performance, e.g., capacity or
 - q Policy related, e.g., security
- q State parameter: Either metric or attribute
- q Link state parameter. Node state parameter.
- q Topology = Link + Nodes
- q Topology state parameter: Link or node state parameter
- q PNNI Topology state element (PTSE):
Routing information that is flooded in a peer group
- q PNNI Topology state packet (PTSP): Contains one PTSE

Topology State Parameters

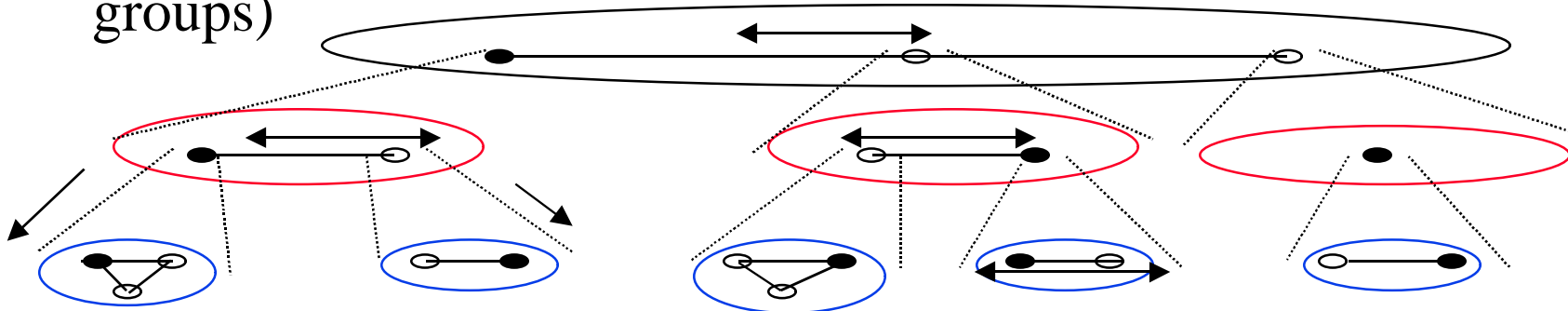
- q Metrics:
 - q Maximum Cell Transfer Delay (MCTD)
 - q Maximum Cell Delay Variation (MCDV)
 - q Maximum Cell Loss Ratio (MCLR)
 - q Administrative weight
- q Attributes:
 - q Available cell rate (ACR)
 - q Cell rate margin (CRM) = Allocated - Actual
First order uncertainty. Optional.
 - q Variation factor (VF) = $CRM / \text{Stdv}(\text{Actual})$
Second order uncertainty. Optional.
 - q Branching Flag: Can handle point-to-multipoint traffic
 - q Restricted Transit Flag: Supports transit traffic or not

Database Synchronization and Flooding

- q Upon initialization, nodes exchange PTSE headers (My topology database is dated 11-Sep-1995:11:59)
- q Node with older database requests more recent info
- q After synchronizing the routing database, they advertise the link between them
- q The ad (PTSP) is *flooded* throughout the peer group
- q Nodes ack each PTSP to the sending neighbors, update their database (if new) and forward the PTSP to all *other* neighbors
- q All PTSEs have a life time and are aged out unless renewed.
- q Only the node that originated a PTSE can reissue it.
- q PTSEs are issued periodically and also event driven.

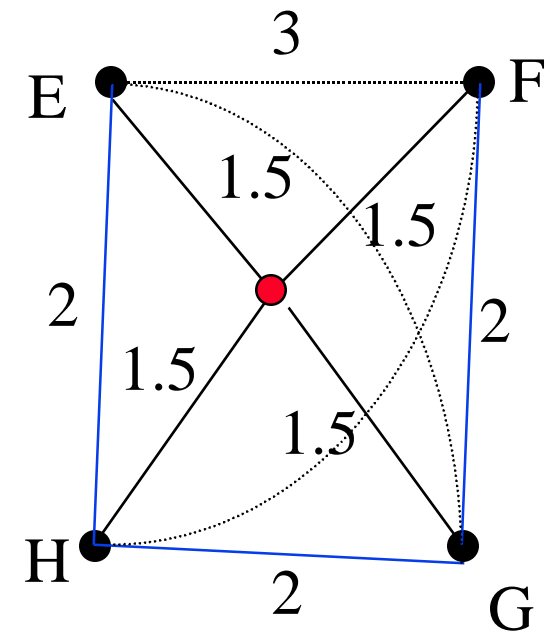
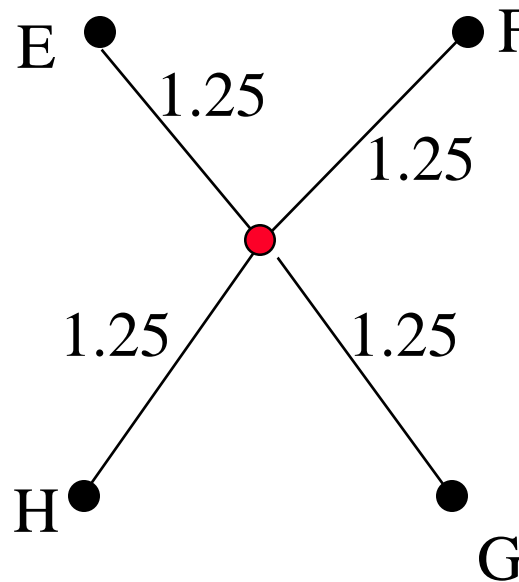
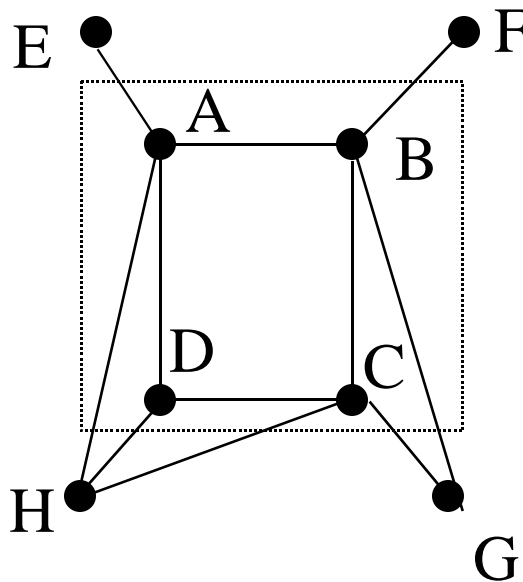
Information Flow in the Hierarchy

- q Information = Reachability and topology aggregation
- q Peer group leaders *summarize* and circulate info in the parent group
- q A raw PTSE never flows upward.
- q PTSEs flow horizontally through the peer group and downward through children.
- q Border nodes do not exchange databases (different peer groups)

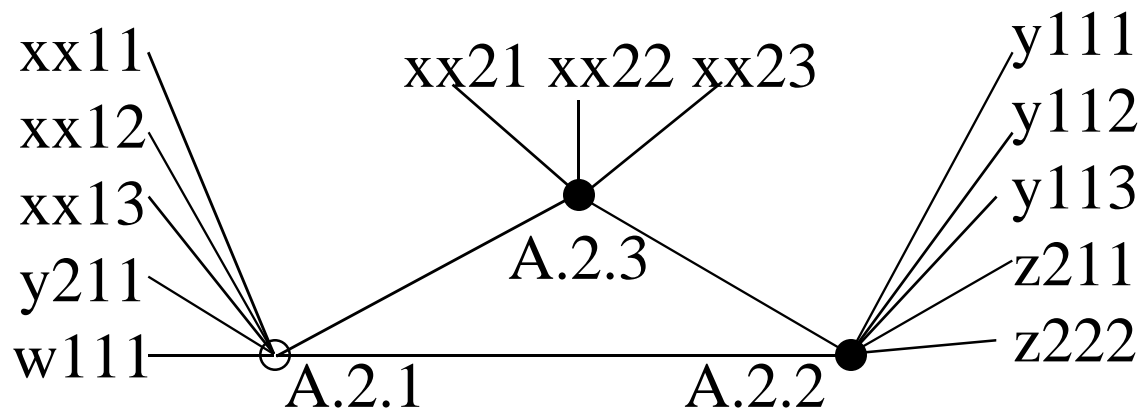


Topology Aggregation

- q Get a simple representation of a group
- q Alternatives: Symmetric star (n links) or mesh ($n^2/2$ links)
- q Compromise: Star with **exceptions**



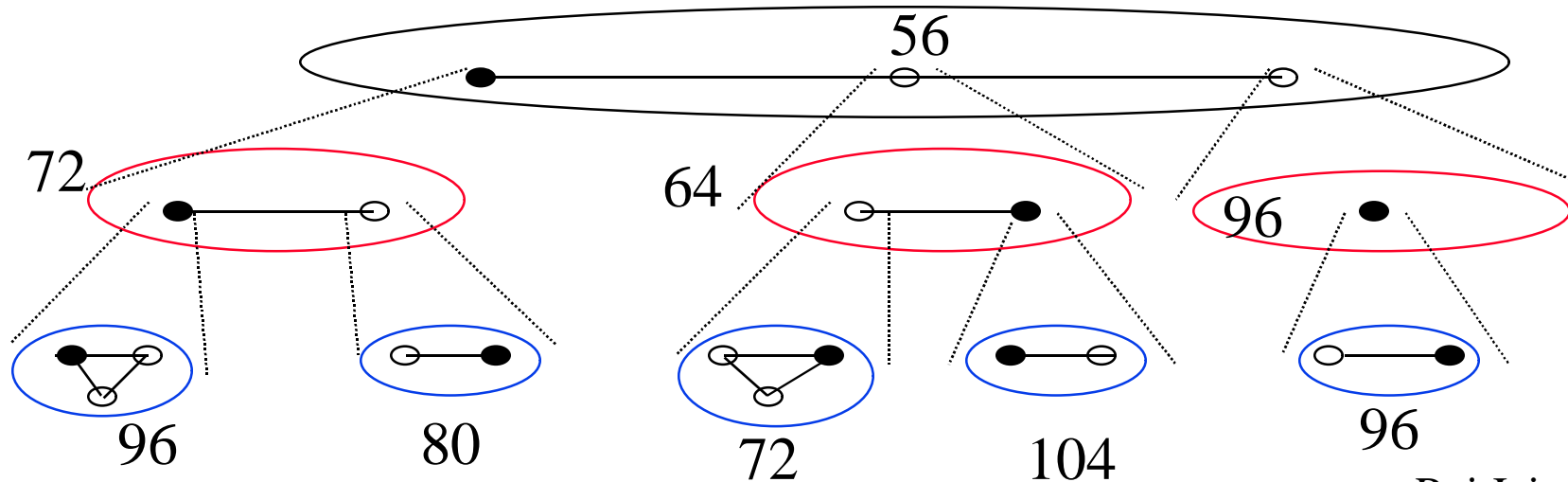
Address Summarization



- q Summary = All nodes with prefix xxx, yyy, ...
+ foreign addresses
- q Native addresses = All nodes with prefix xxx, yyy, ...
- q **Example:**
 - q A.2.1 = XX1*, Y2*, W111 A.2.2 = Y1*, Z2*
 - q A.2.3 = XX2*
 - q A.2 = XX*, Y*, Z2*, W111. W111 is a foreign address

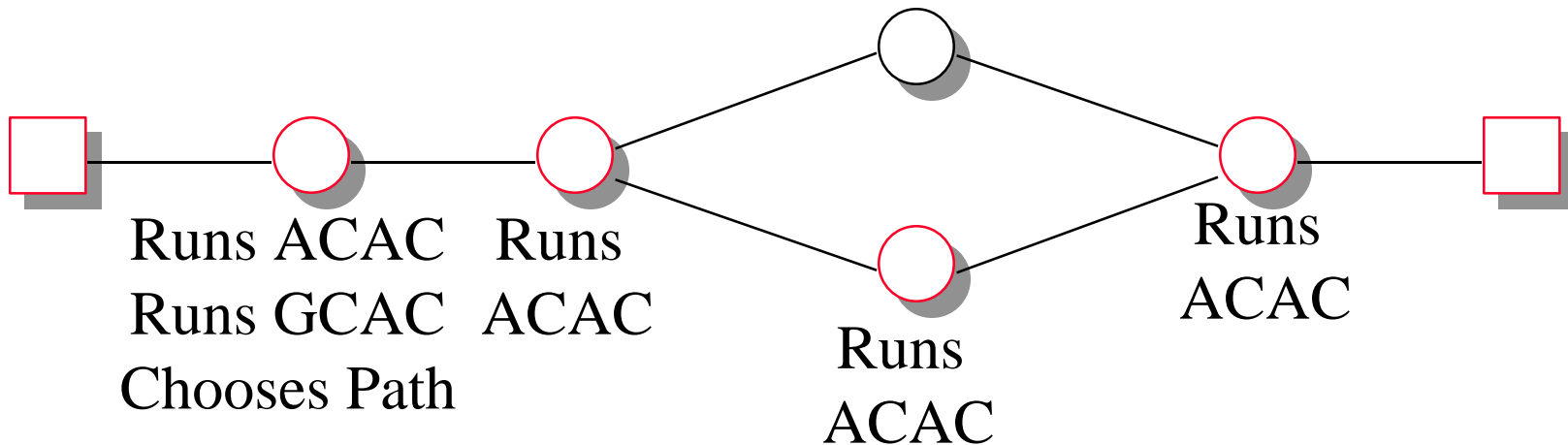
Address Scope

- q Upward distribution of an address can be inhibited, if desired.
E.g., Don't tell the competition B that W111 is reachable via A.
- q Each group has a level (length of the shortest prefix).
- q Each address has a scope (level up to which it is visible).



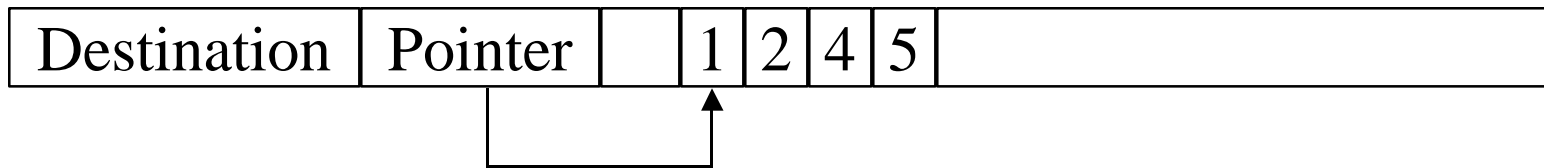
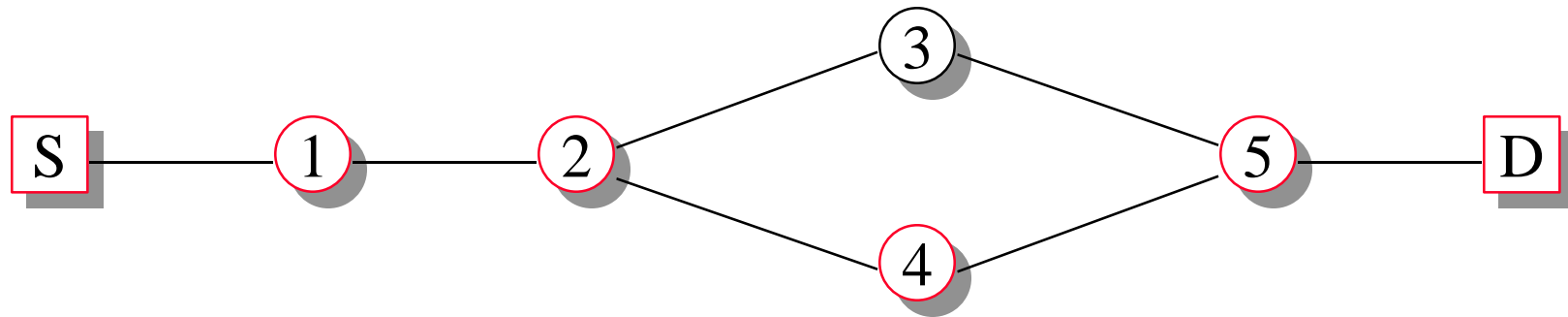
Call Admission Control

- q Generic Call Admission Control (GCAC)
 - q Run by a switch in choosing a source route
 - q Determines which path can probably support the call
- q Actual Call Admission Control (ACAC)
 - q Run by each switch
 - q Determines if it can support the call



Source Routing

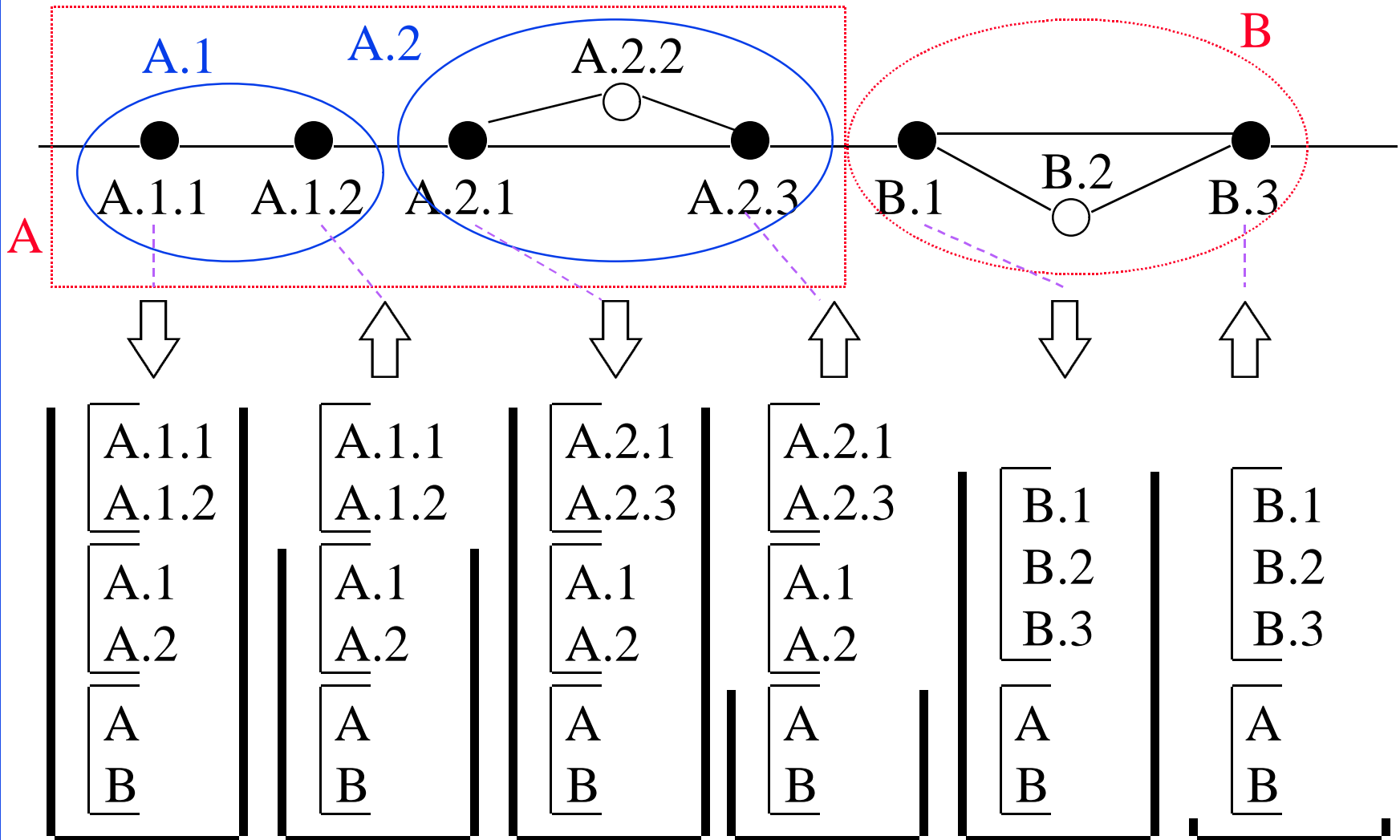
- q Used in IEEE 802.5 token ring networks
- q Source specifies all intermediate systems (bridges) for the packet



Designated Transit Lists

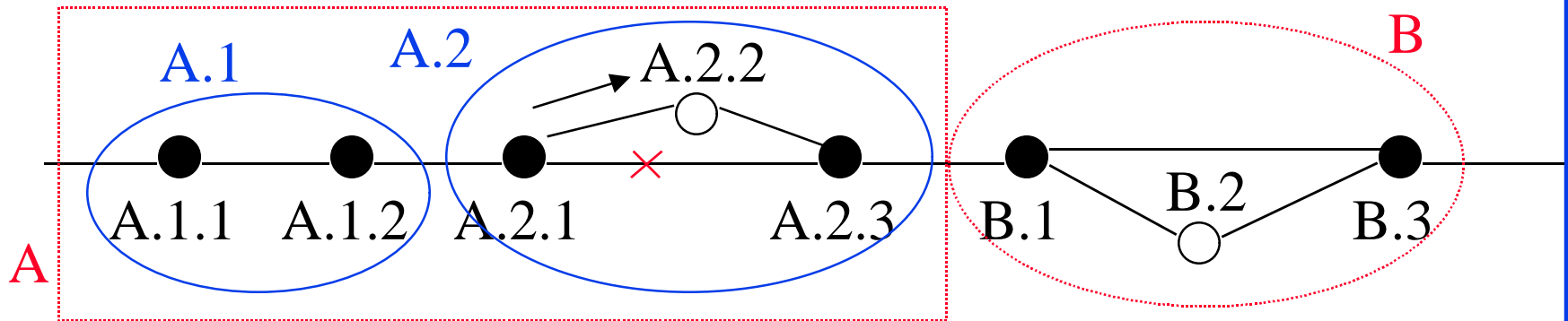
- q DTL: Source route across each level of hierarchy
- q Entry switch of each peer group specifies complete route through that group
- q Entry switch may or may not be the peer group leader
- q Multiple levels \Rightarrow Multiple DTLs
Implemented as a stack

DTL: Example

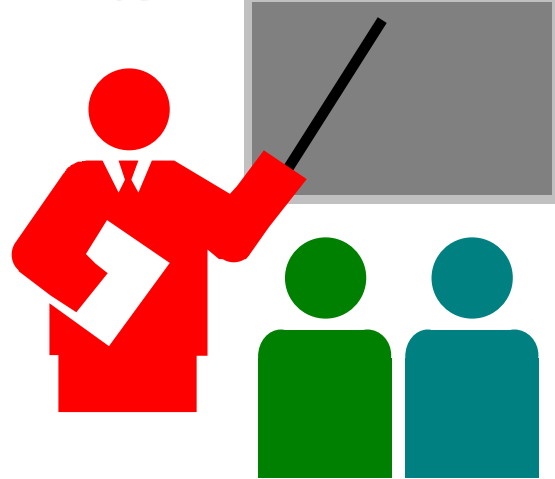


Crankback and Alternate Path Routing

- q If a call fails along a particular route:
 - q It is *cranked back* to the originator of the top DTL
 - q The originator finds another route *or*
 - q Cranks back to the generator of the higher level source route



Summary



- q Database synchronization and flooding
- q Hierarchical grouping: Peer groups, group leaders
- q Topology aggregation and address summarization
- q Designated transit lists
- q Crankback

Homework

- q Read section 15.5 of McDysan's book