

PNNI: Routing in ATM Networks

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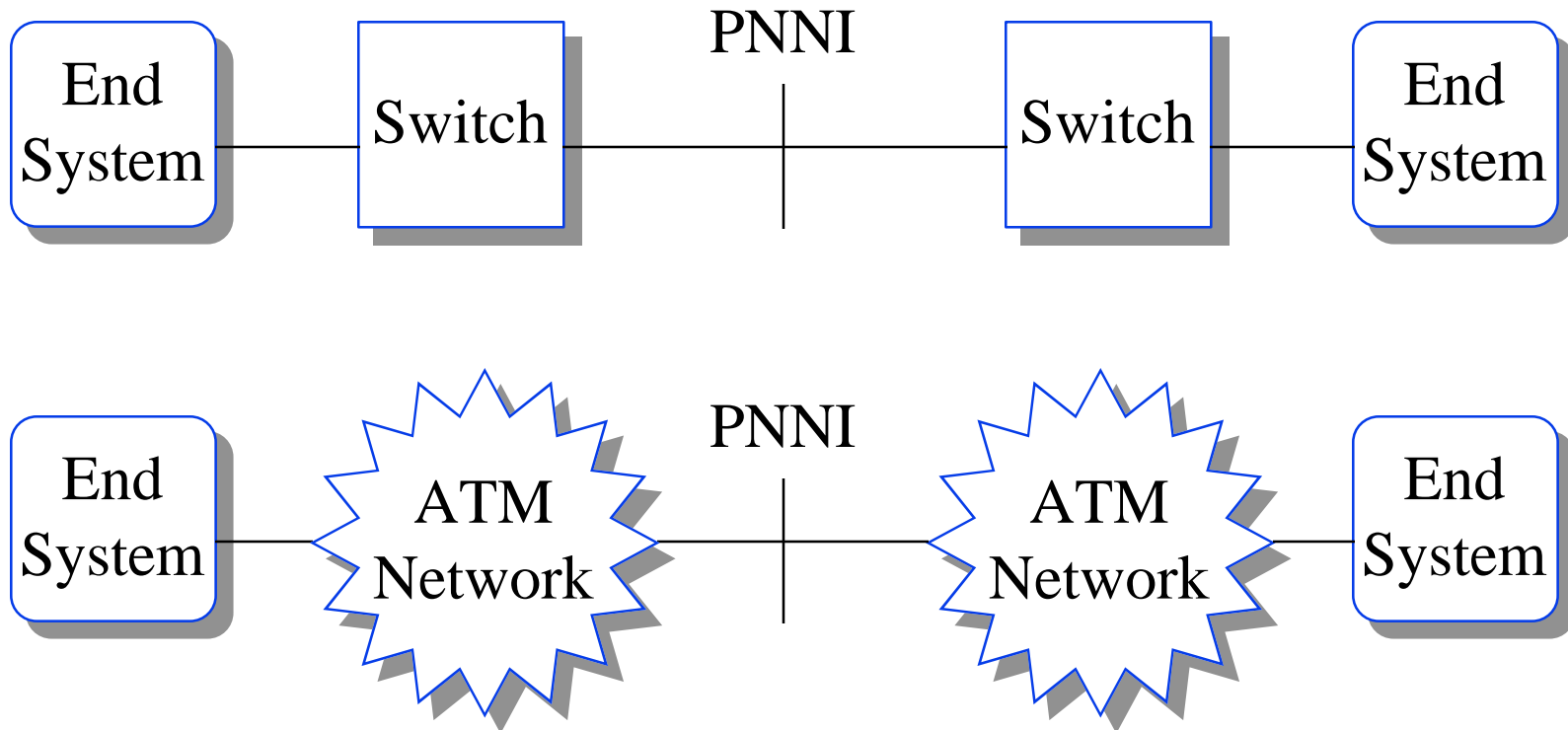
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- ❑ Distribution of topology information
- ❑ Hierarchical groups
- ❑ Source routing \Rightarrow Designated Transit Lists
- ❑ Crankback and Alternate routing
- ❑ Addressing

Ref: ATM Forum 94-0471R9, "PNNI Draft Specification
(Phase 1)"

PNNI



- ❑ Private Network-to-network Interface
- ❑ Private Network Node Interface

Features of PNNI

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

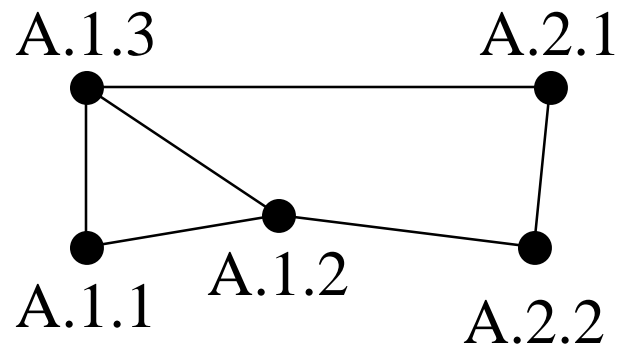
Addressing

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

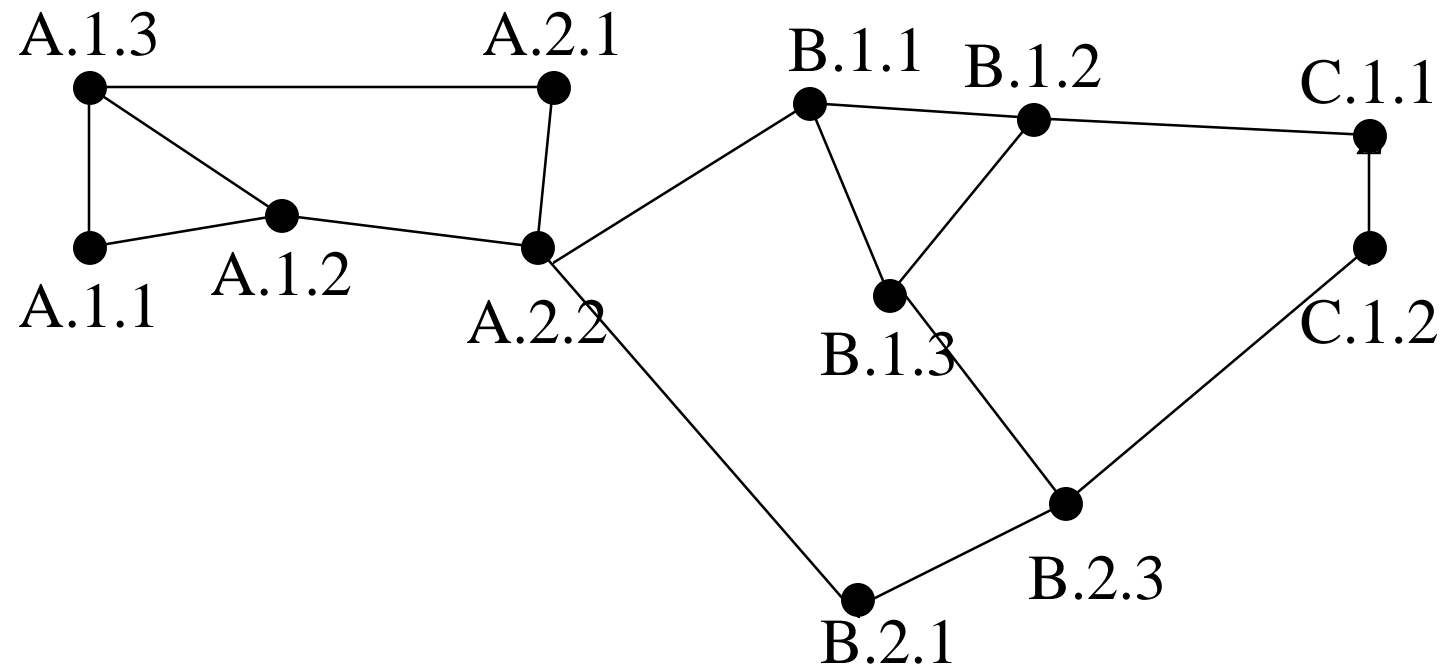


Link State Routing

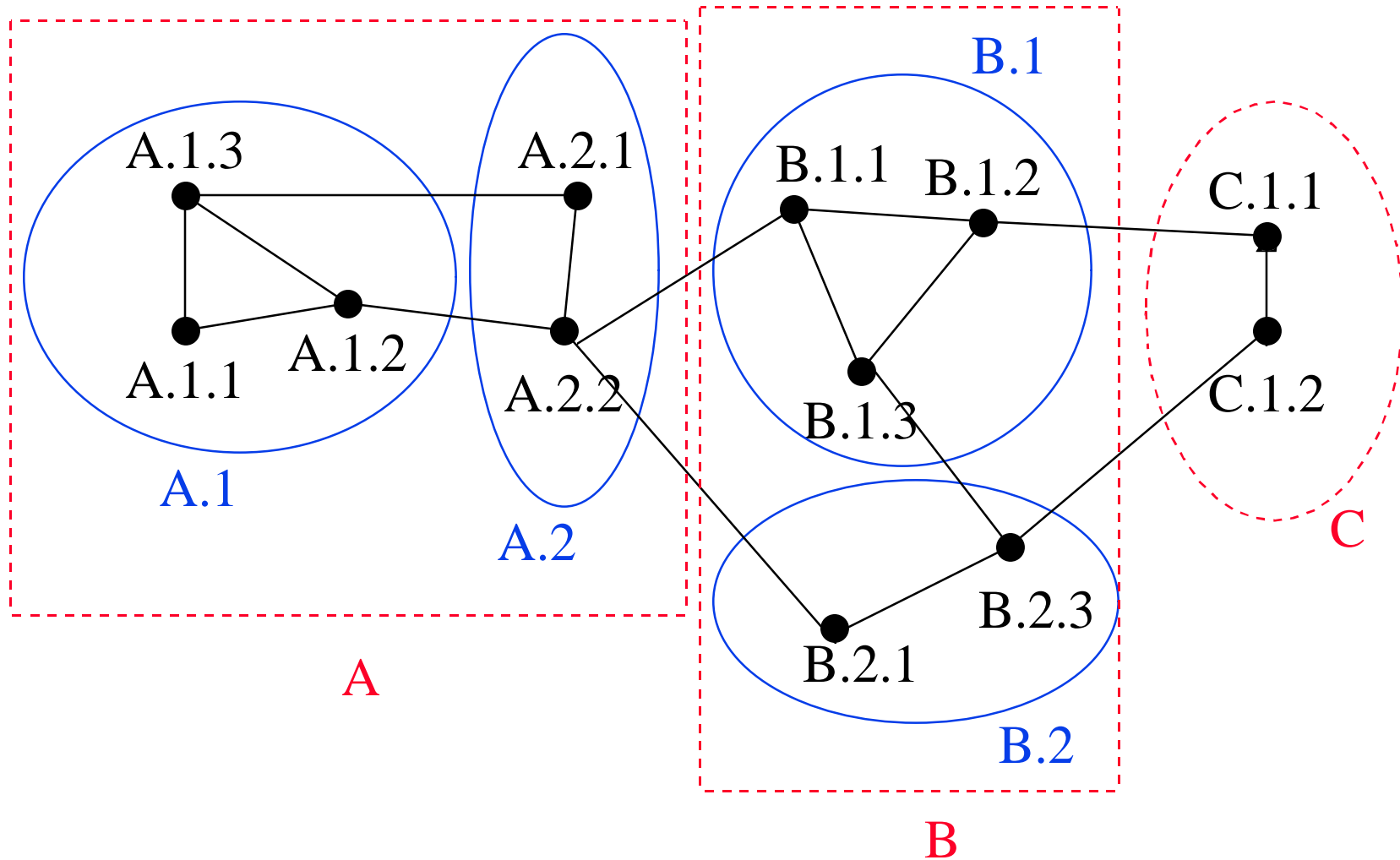
- ❑ Each node sends “Hello” packets periodically and on state changes.
- ❑ The packet contains state of all its links
- ❑ The packet is flooded to all nodes in the network



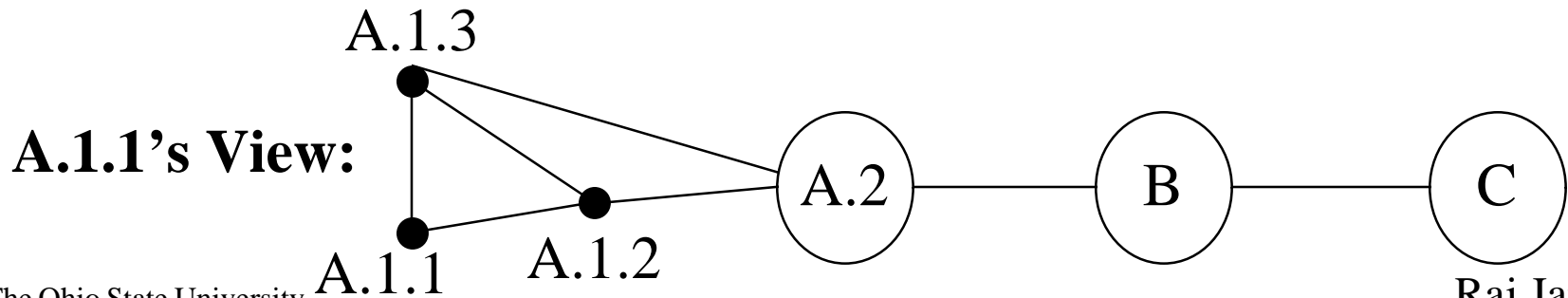
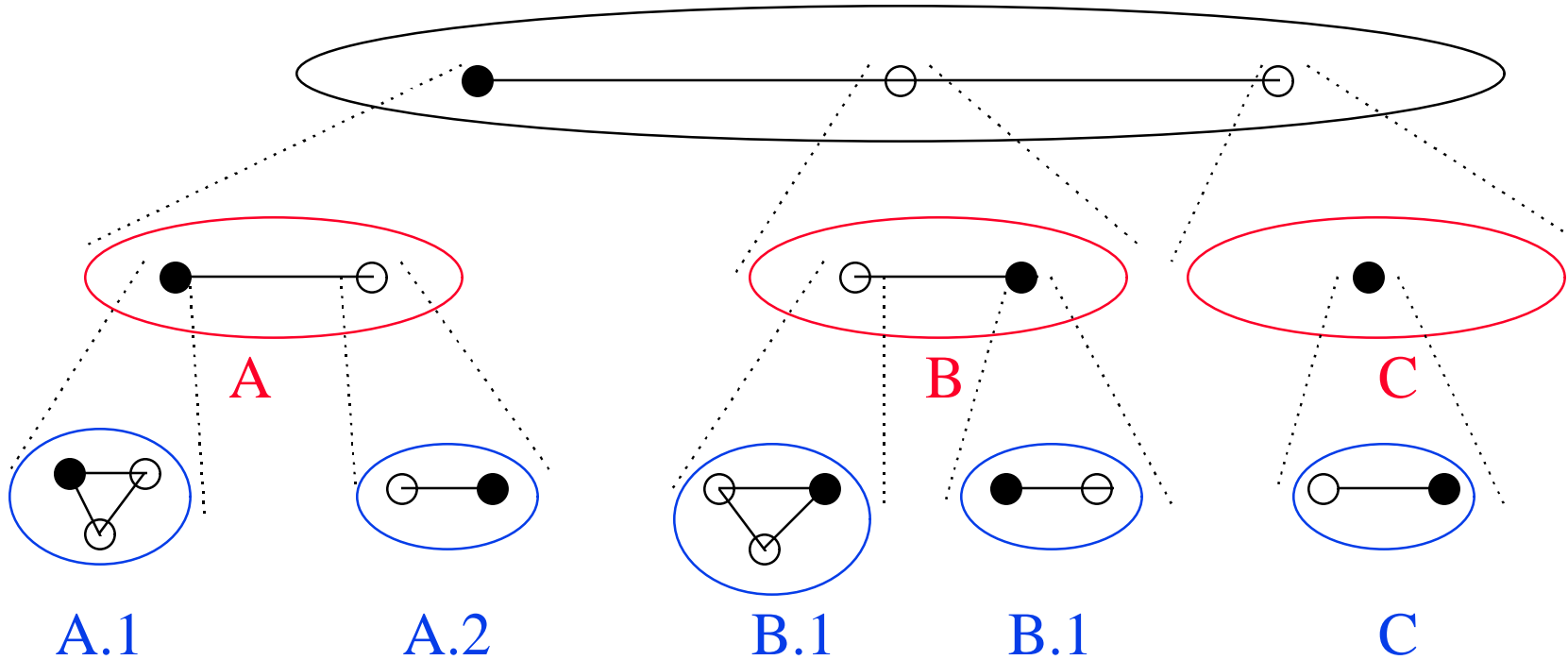
Very Large Networks



Hierarchical Layers



Hierarchical View



Terminology

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

- ❑ 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.
- ❑ PGL acts as a logical group node.
Uses same ATM address with a different selector value.
- ❑ Peer group ID: Address prefixes up to 13 bytes

Topology State Information

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

Topology State Parameters

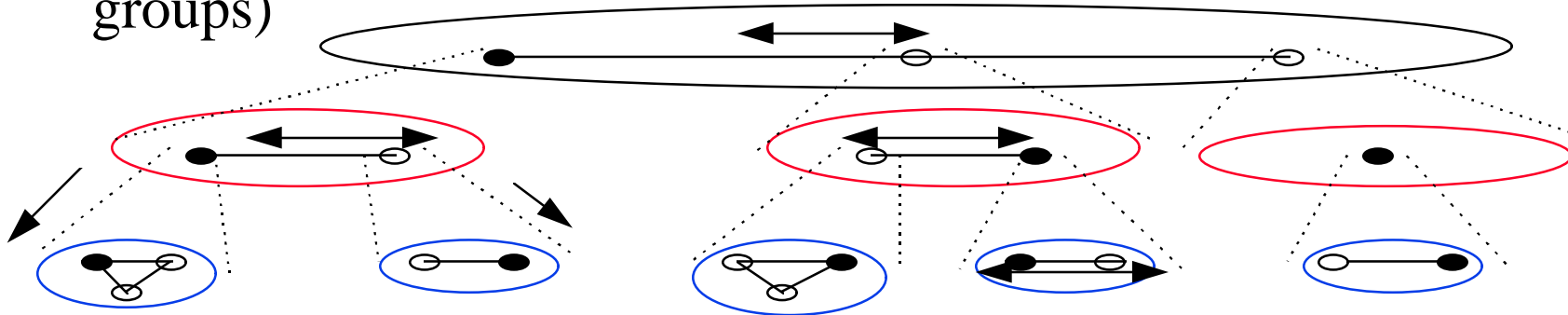
- ❑ Metrics:
 - ❑ Maximum Cell Transfer Delay (MCTD)
 - ❑ Maximum Cell Delay Variation (MCDV)
 - ❑ Maximum Cell Loss Ratio (MCLR)
 - ❑ Administrative weight
- ❑ Attributes:
 - ❑ Available cell rate (ACR)
 - ❑ Cell rate margin (CRM) = Allocated - Actual
First order uncertainty. Optional.
 - ❑ Variation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

Database Synchronization and Flooding

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

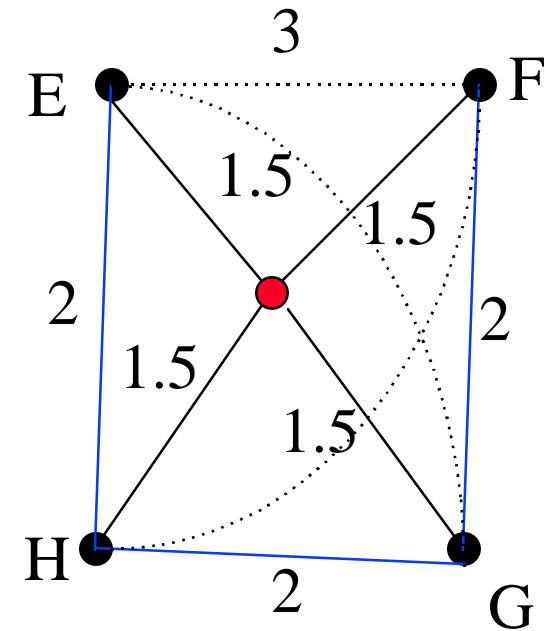
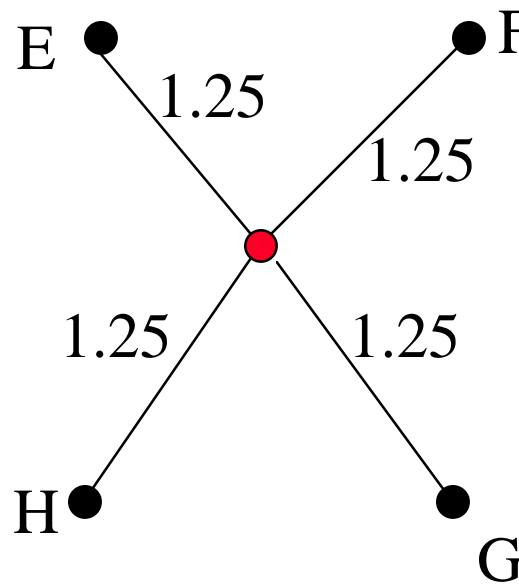
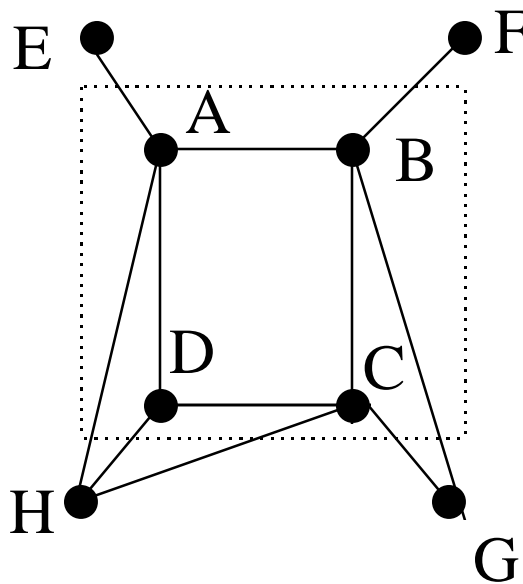
Information Flow in the Hierarchy

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

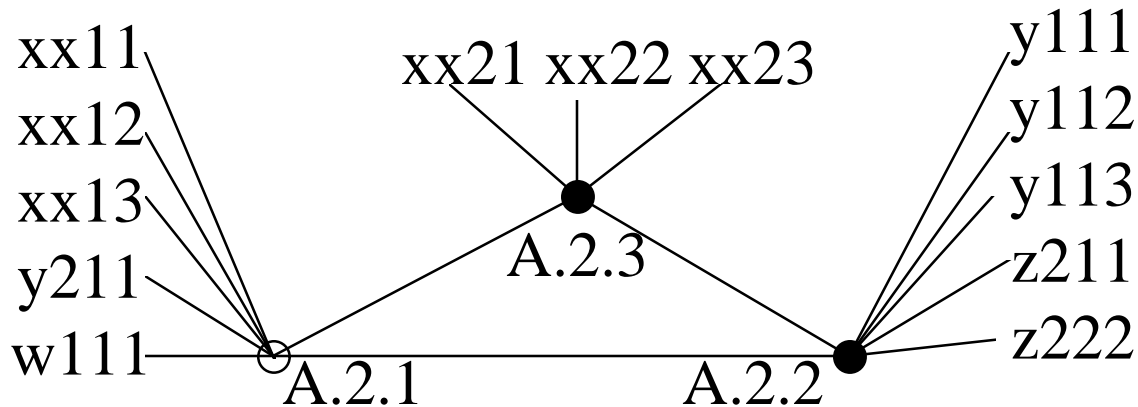


Topology Aggregation

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



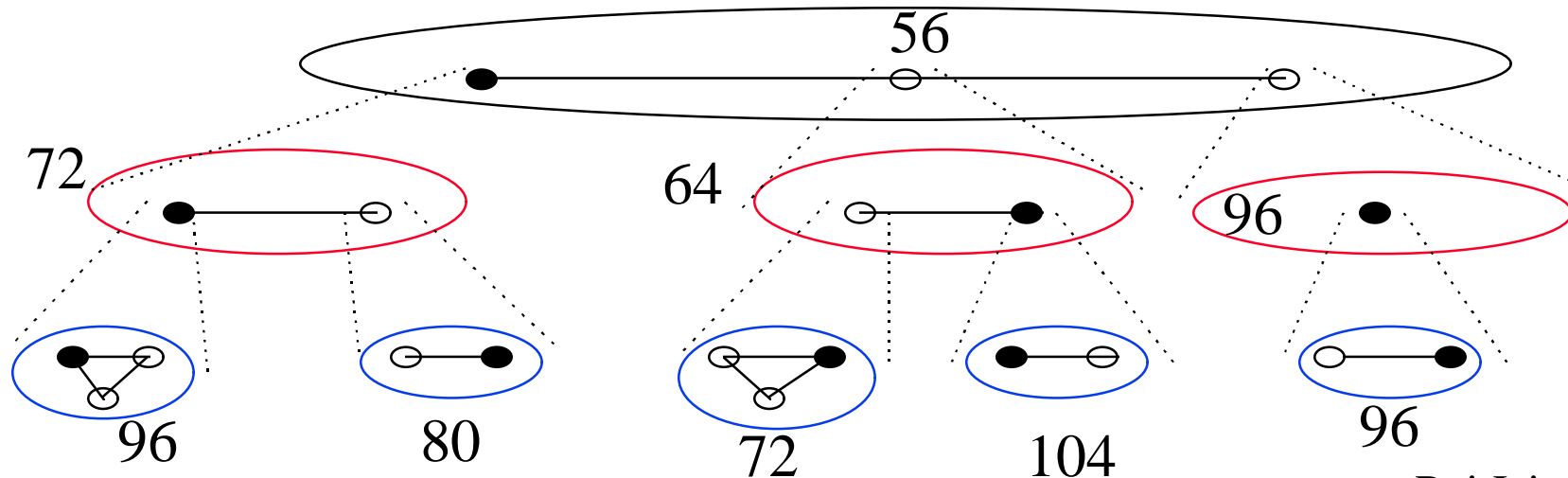
Address Summarization



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

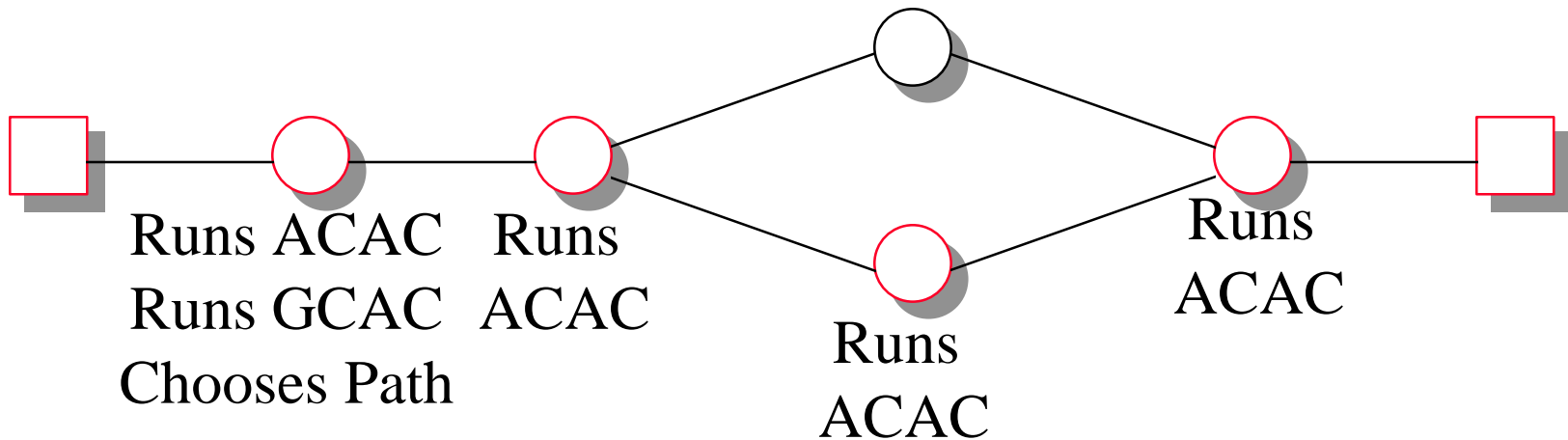
Address Scope

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



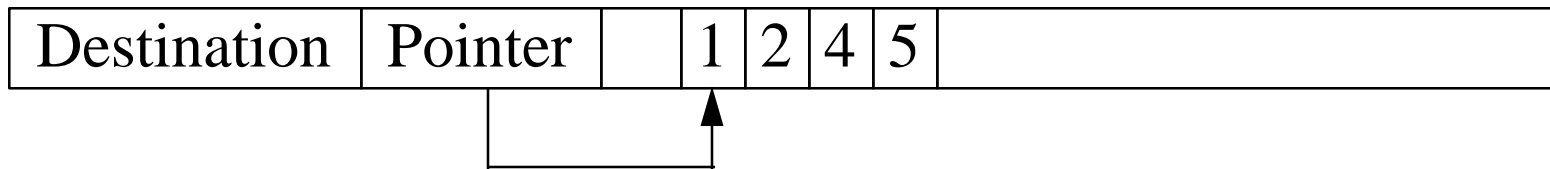
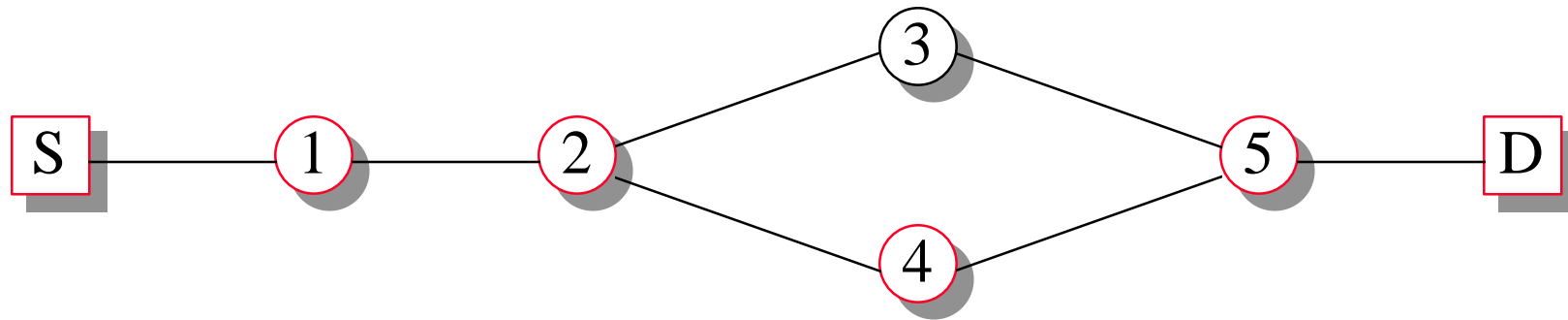
Call Admission Control

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



Source Routing

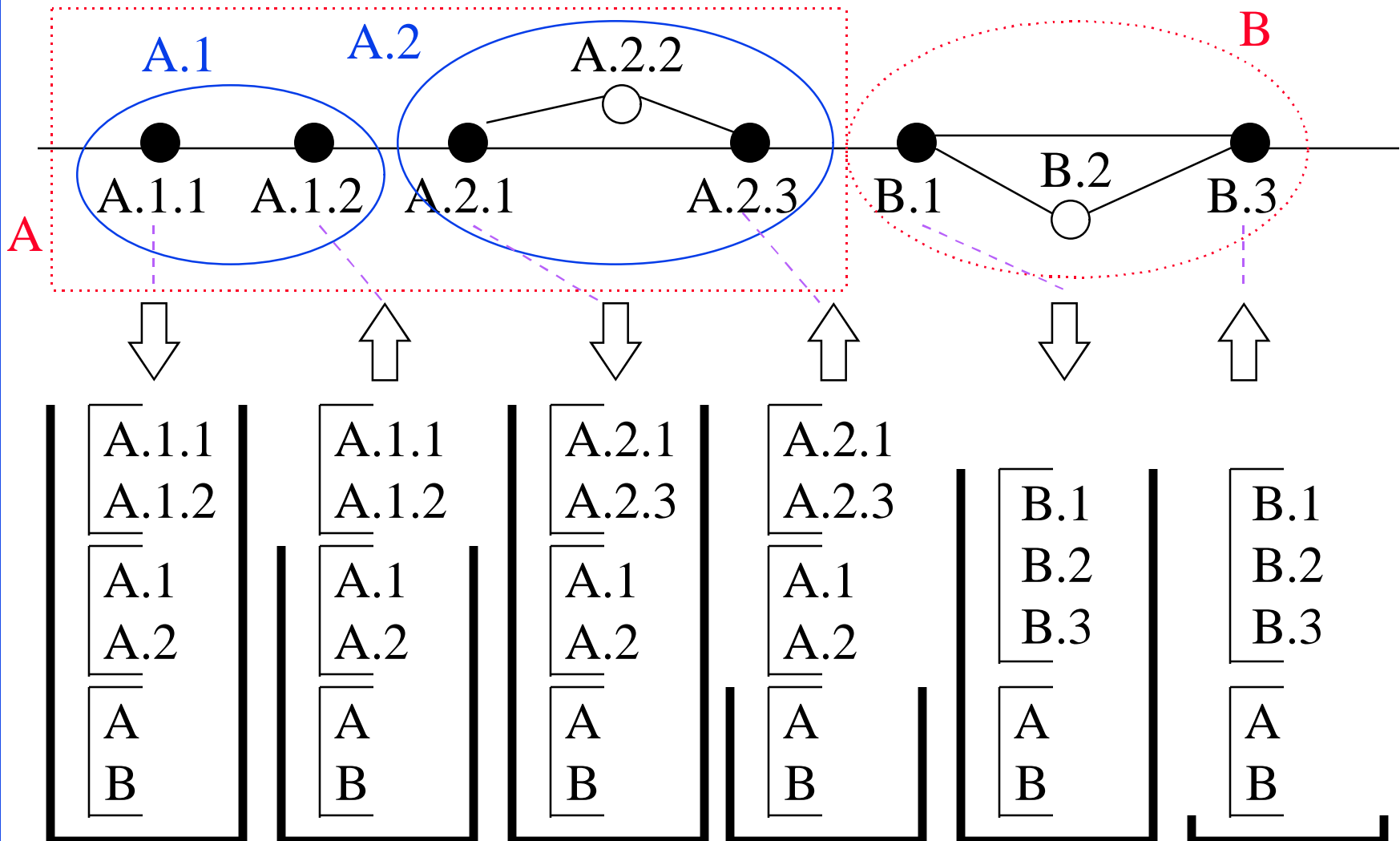
- ❑ Used in IEEE 802.5 token ring networks
- ❑ Source specifies all intermediate systems (bridges) for the packet



Designated Transit Lists

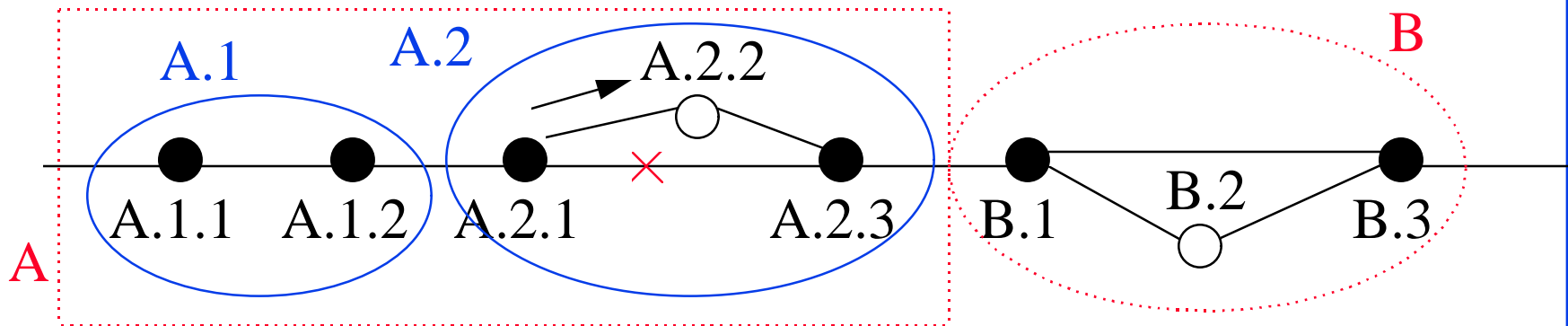
- ❑ DTL: Source route across each level of hierarchy
- ❑ Entry switch of each peer group specifies complete route through that group
- ❑ Entry switch may or may not be the peer group leader
- ❑ Multiple levels \Rightarrow Multiple DTLs
Implemented as a stack

DTL: Example

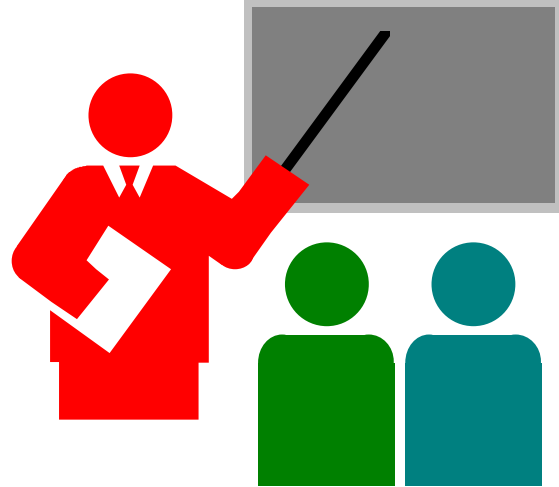


Crankback and Alternate Path Routing

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



Summary



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

Abbreviations

- ❑ AFI Authority and format identifier
- ❑ BIS Border intermediate system
- ❑ BISPDU Border intermediate system protocol data unit
- ❑ CAC Connection admission control
- ❑ CNR Complex node representation
- ❑ CRM Cell rate margin
- ❑ DSP Domain specific part
- ❑ DTL Designated transit list
- ❑ ES End system
- ❑ ESI End system identifier
- ❑ GCAC Generic connection admission control

- ❑ IDI Initial domain identifier
- ❑ IDP Initial domain part
- ❑ IS Intermediate system
- ❑ LGN Logical group node
- ❑ LSAP Link service access point
- ❑ MaxCR Maximum cell rate
- ❑ NPDU Network protocol data unit
- ❑ NSAP Network service access point
- ❑ OSPF Open shortest path first
- ❑ PG Peer group
- ❑ PGL Peer group leader
- ❑ PTSE PNNI Topology state element
- ❑ PTSP PNNI Topology state packet

- ❑ PNNI Private network-network interface
- ❑ PVCC Permanent virtual channel connection
- ❑ PVPC Permanent virtual path connection
- ❑ RD Routing domain
- ❑ SAAL Signaling ATM adaptation layer
- ❑ SNPA Subnetwork point of attachment
- ❑ TIG Topology information group
- ❑ TLV Type, length, value
- ❑ VF Variance factor

References

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