Link-Layer Broadcast Protocol for SpaceWire

SpaceWire Working Group Meeting

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Overview

- Motivation & Value
- Protocol Features
- Protocol Description
- Performance
- Relationship to PnP

Motivation & Value

- **Reduce software development time & cost**
  - **Broadcast support for IP & non-IP applications**
  - **Reuse existing software**
  - **Simplify new software**
  - **Use IP configuration & management tools**

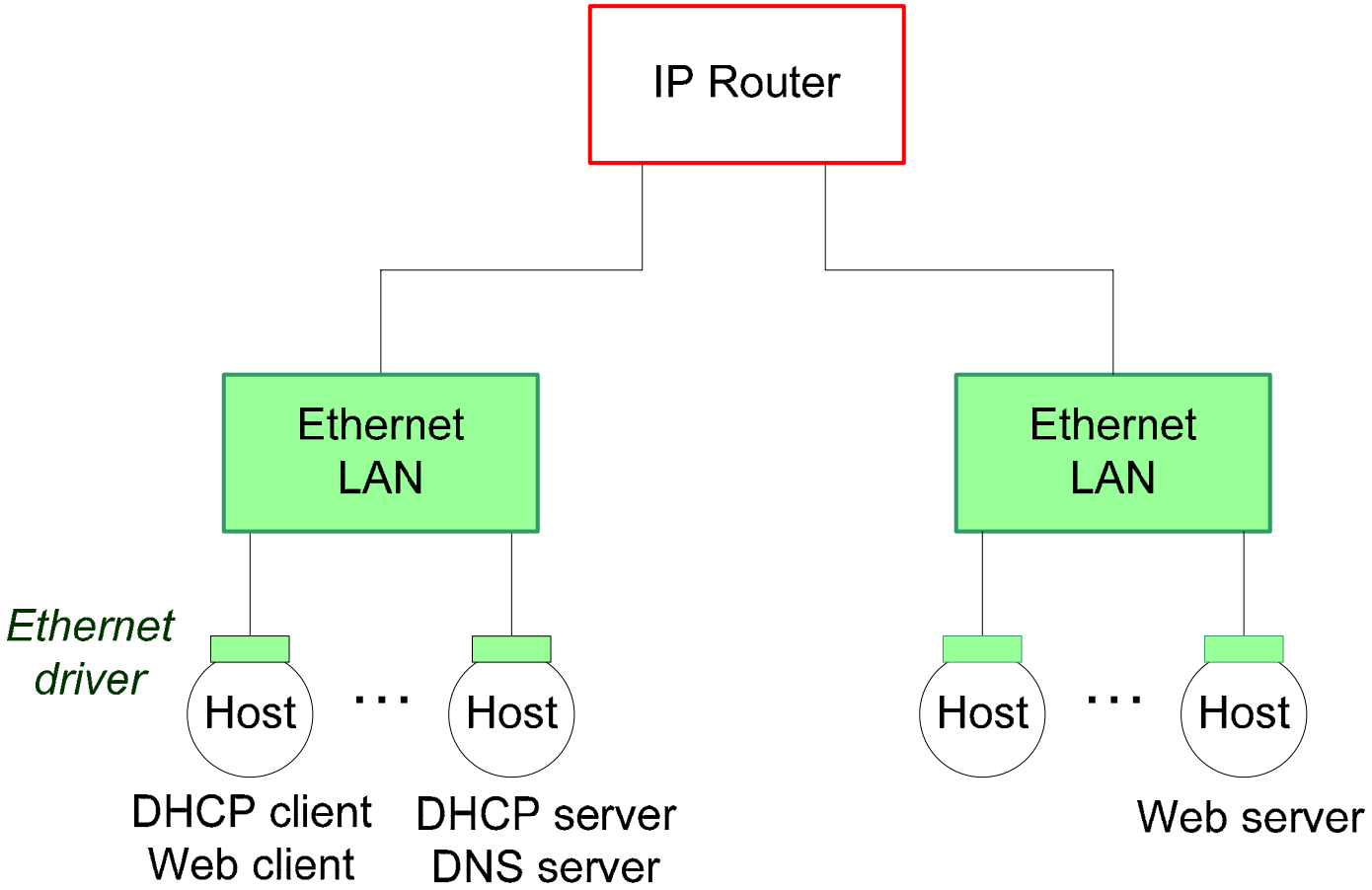
    ARP, DHCP, SNMP broadcast, Service Discovery (DNS, FTP, …)

- **Improve network performance***
  - **Reduce router load**
  - **Reduce contention at switches**
  - **Reduce broadcast latency**

**** vs. sequential unicast***

IP Over SpaceWire

Same application software on SpaceWire & Ethernet LANs



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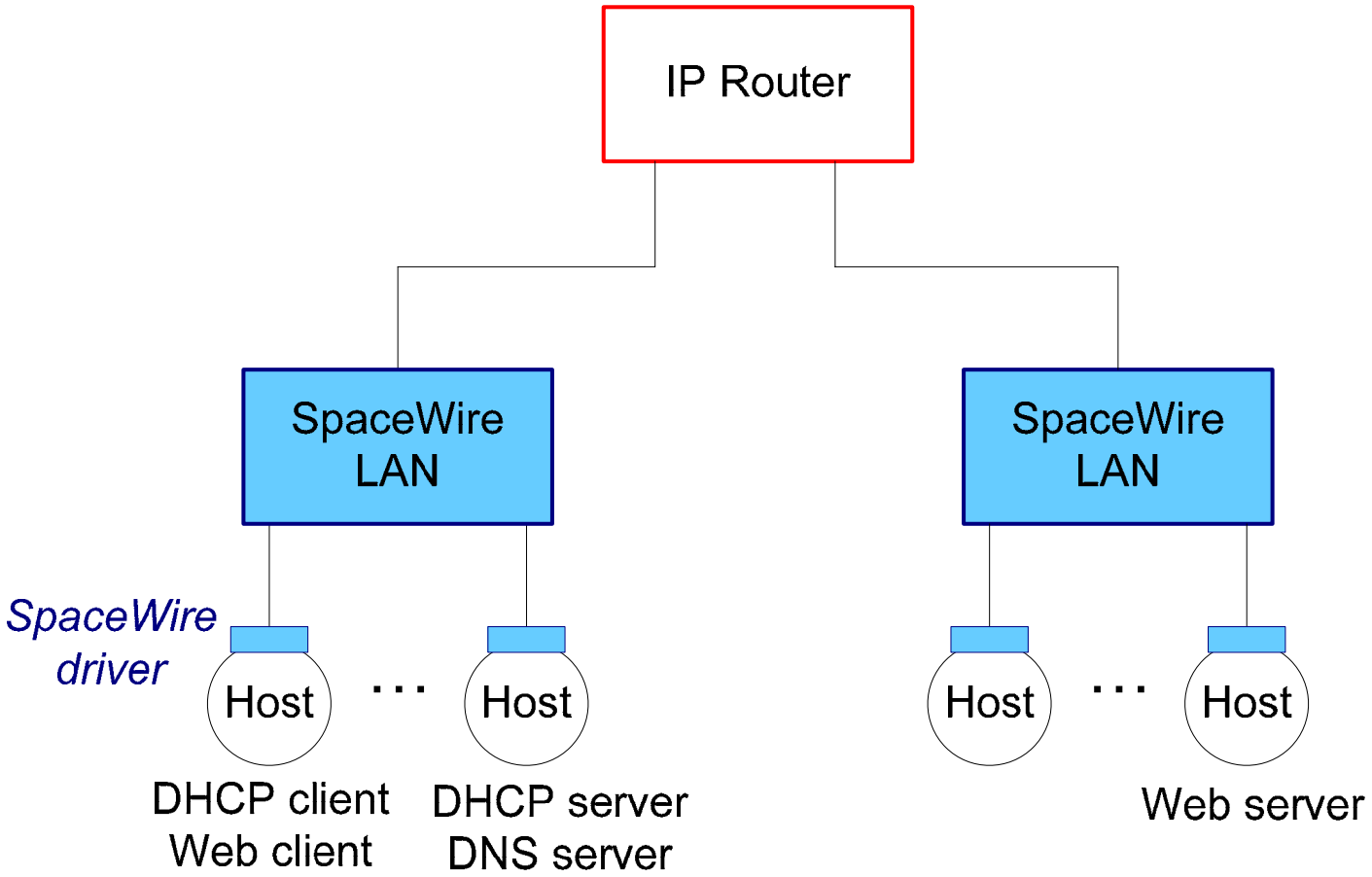

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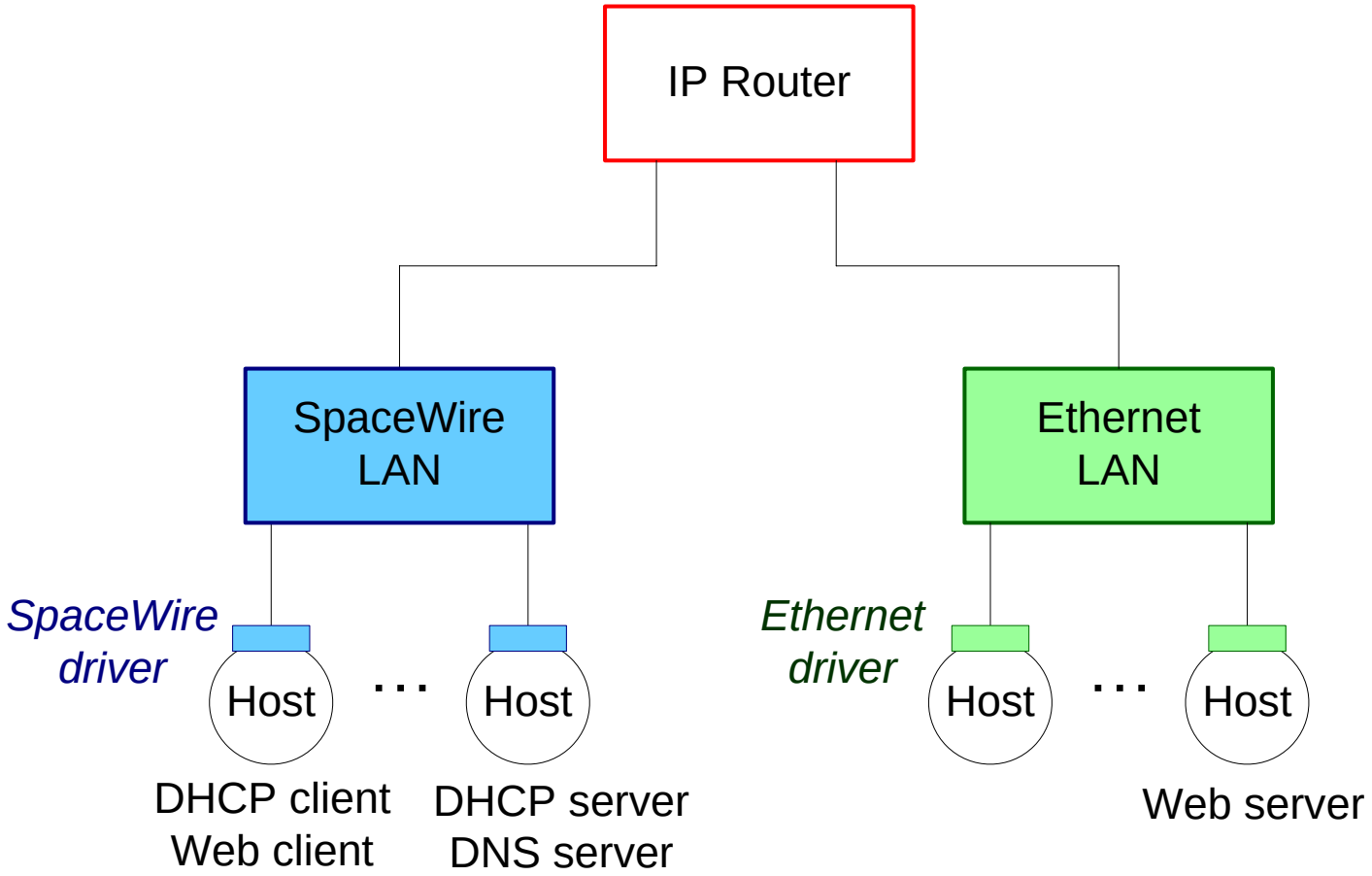
Same application software on SpaceWire & Ethernet LANs



What is Needed?

- **Broadcast support**
- **Unique hardware address**
  - **Required for ARP**
  - **SpW logical address is unique only within a region**
  - **Need to ARP across regions**

(Automatic assignment of hardware addresses and a SpW routing protocol would simplify network management, but these are layer 2 issues and have no affect on IP applications.)

Ethernet Broadcast

- **Application Software**

  `IP_dest = 255.255.255.255`

- **Kernel / driver ARP**

  `Protocol  255.255.255.255`

  `Hardware  ff:ff:ff:ff:ff:ff`

- **Ethernet Switch**

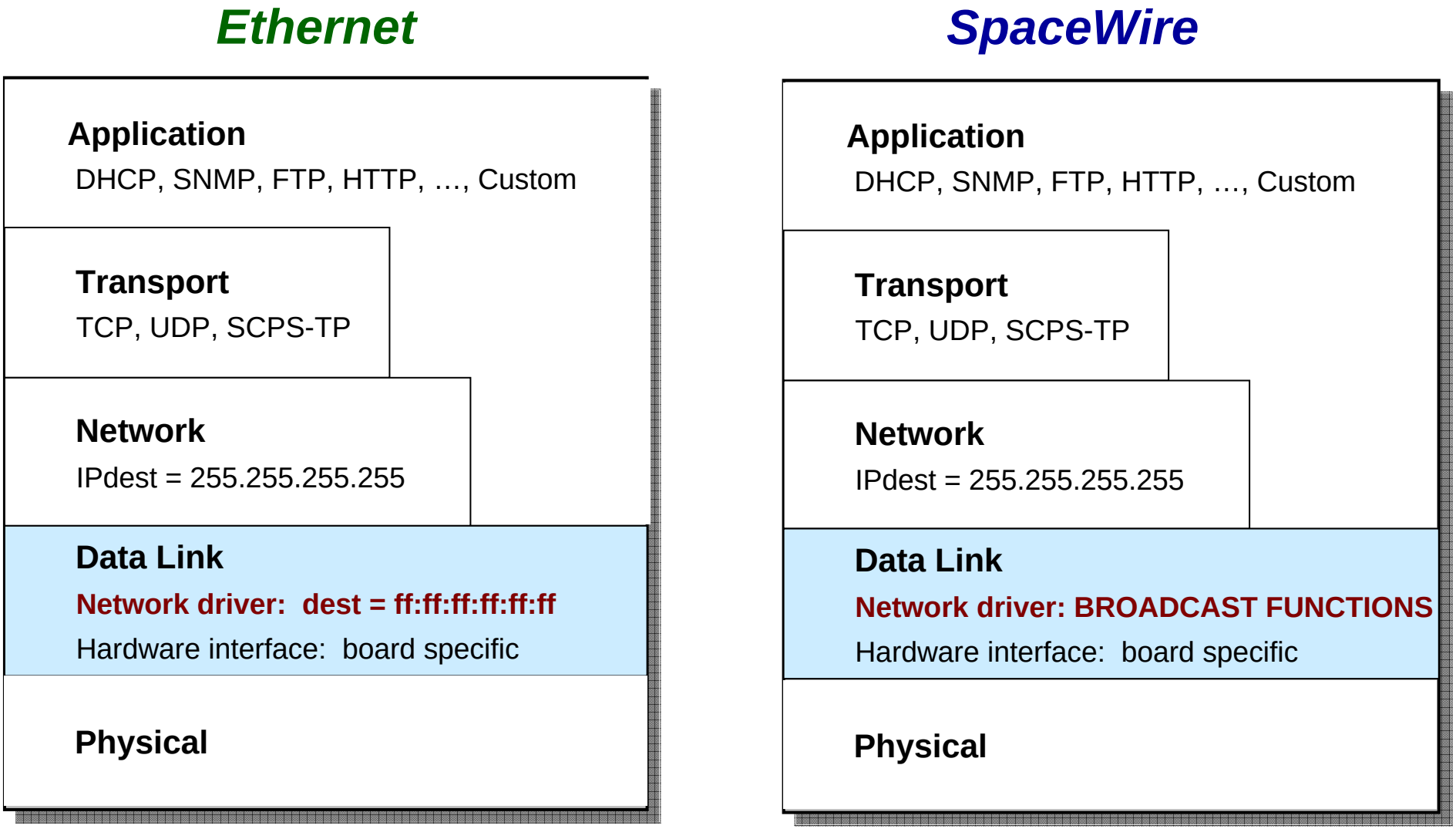
  `ff:ff:ff:ff:ff:ff ⇒ transmit on all ports`

All complexity is in switch; spanning tree algorithm prevents broadcast storms from loops.

SpaceWire Broadcast

- **Implement in router or host?**
- **Router**
  - Cleaner solution; better for network management
  - Impact on chip complexity, weight, power?
  - Not available anytime soon
- **Host**
  - In network driver; transparent to applications
  - Minimal configuration
  - Efficient
  - Rapid to develop and prototype

Network Stack Interface



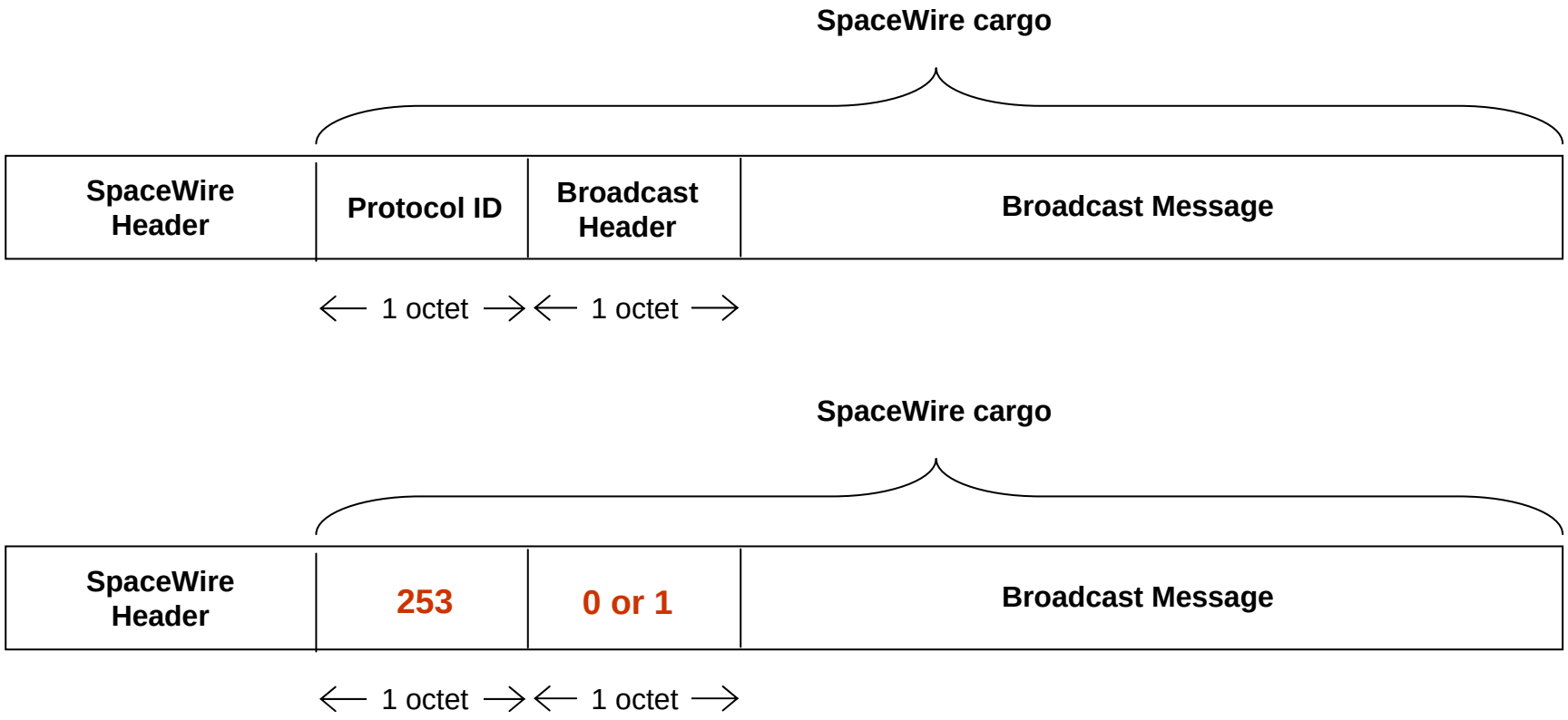
Broadcast code is independent of hardware interface code.

Features

- Loop-free broadcast
- Adheres to SpaceWire standard
- No change to SpW routers
- No change to SpW interface hardware
- No change to applications
- Co-exist with PnP proposal.

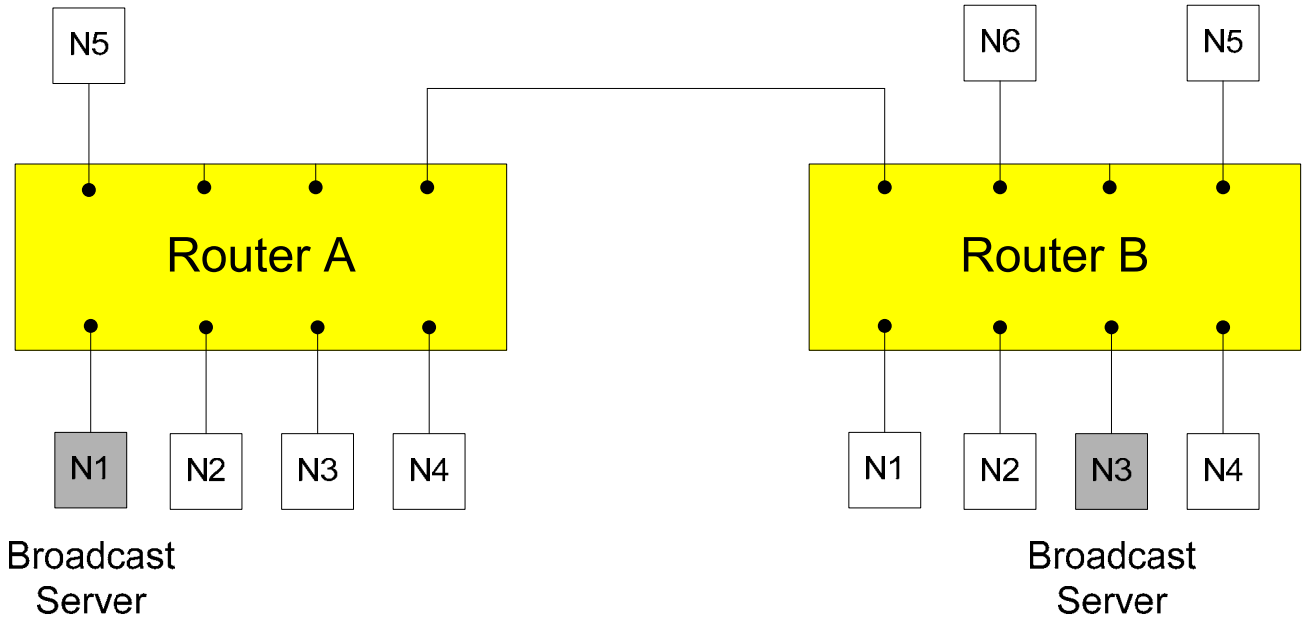
Broadcast Packets

Using Protocol ID 253



Protocol Operation

- One node per router acts as a Broadcast server (BcS)
- Additional nodes may serve as backup BcS's for redundancy
- 1-byte broadcast header
- Two message types: Type 0, Type 1
- Three step protocol



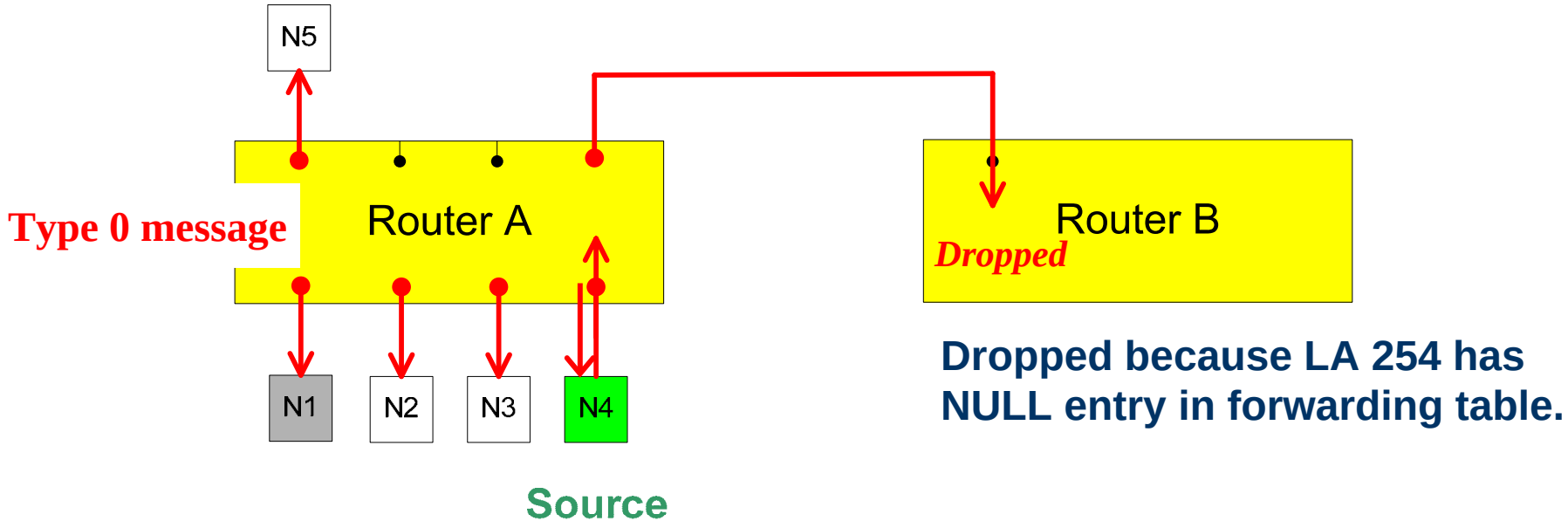
Step 1

Source Node sends Type 0 message to all ports on local router:

<1><254><253><0><data>

<2><254><253><0><data>

…

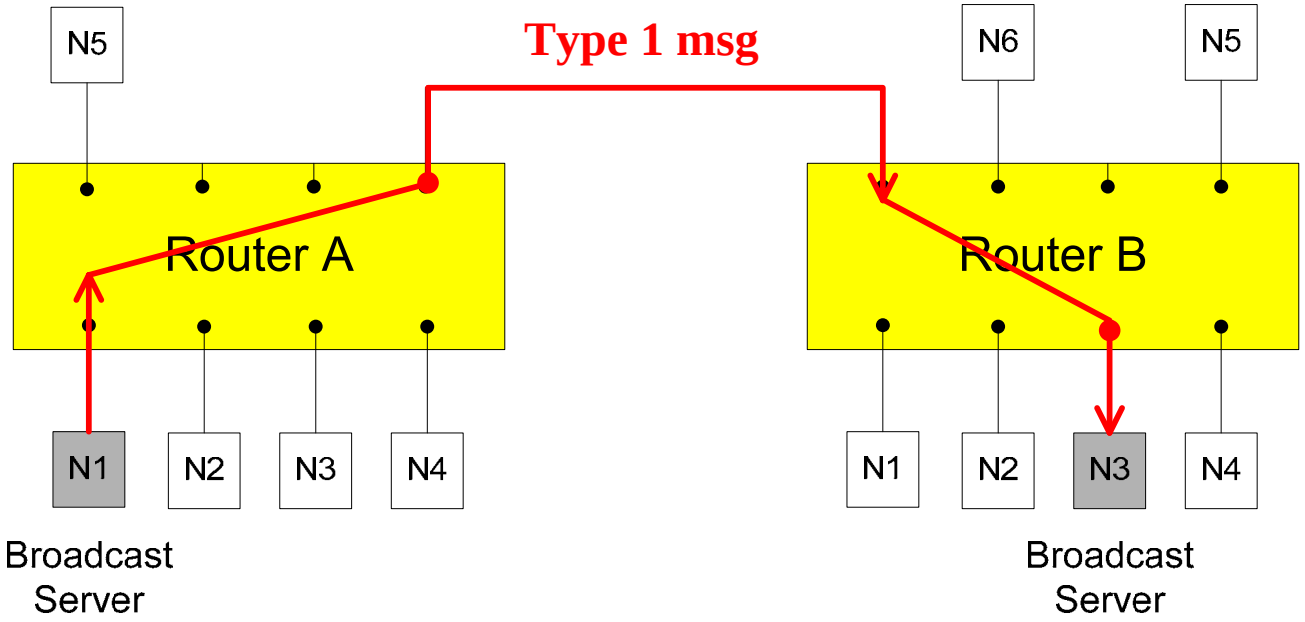


Dropped because LA 254 has NULL entry in forwarding table.

Step 2

<u>Local BcS</u> sends Type 1 message to other BcS's:

<LA><253><1><data> ***logical and/or port addresses.***



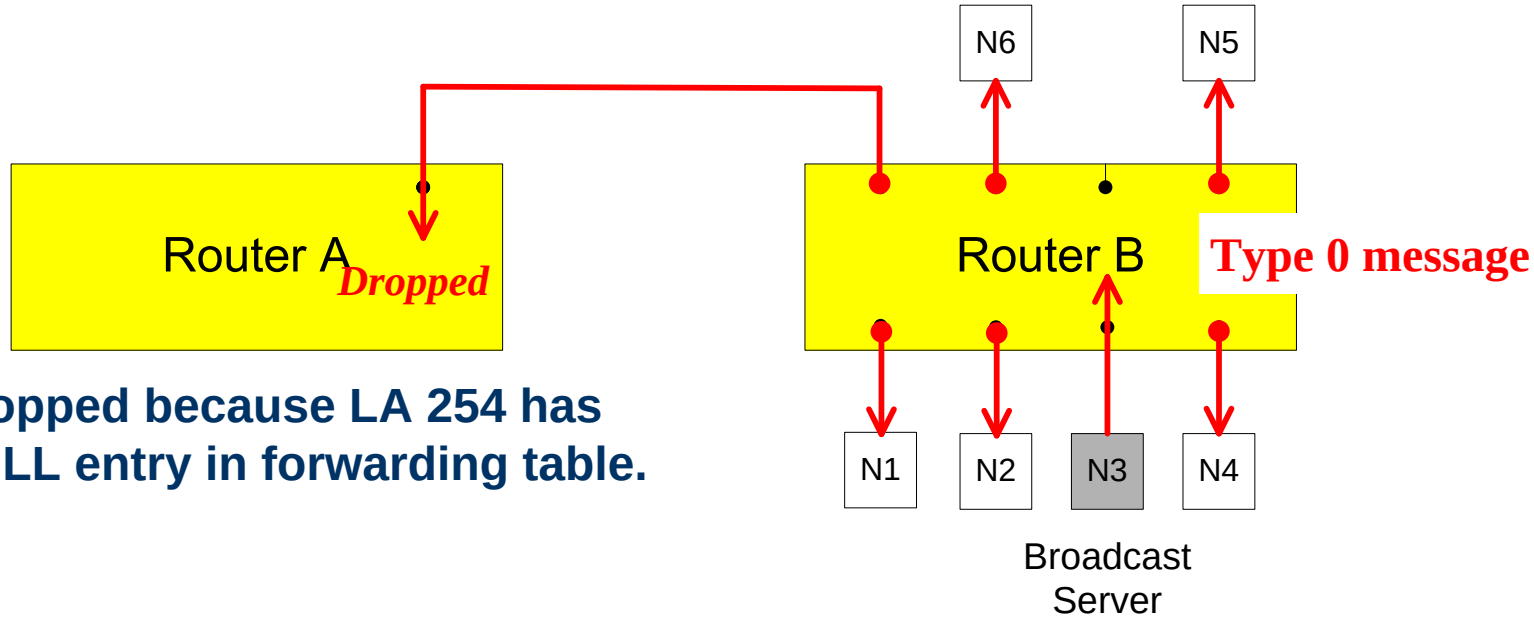
Step 3

<u>Remote BcS</u> sends Type 0 message to all ports except itself:

<1><254><253><0><data>

<2><254><253><0><data>

…



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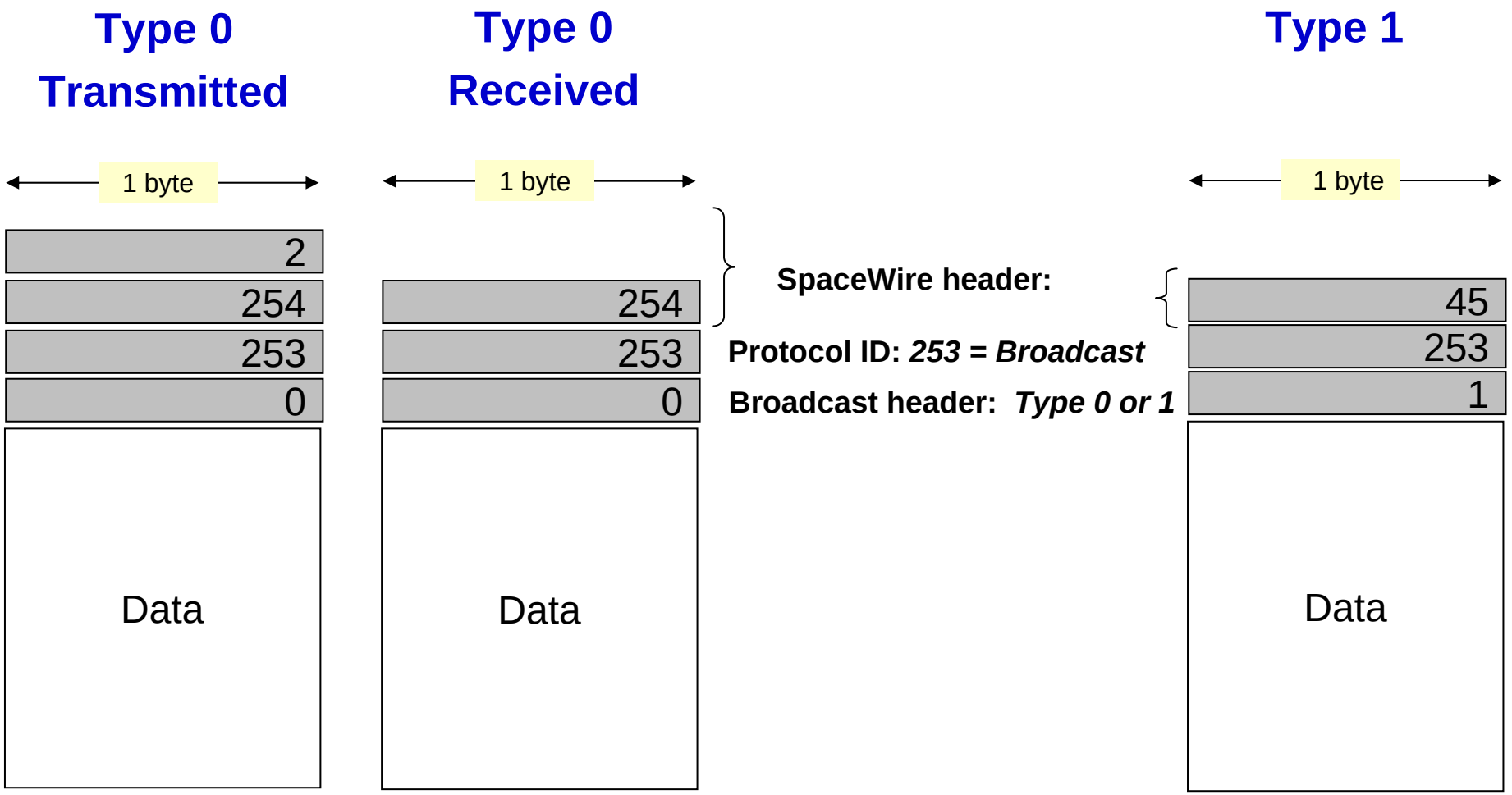
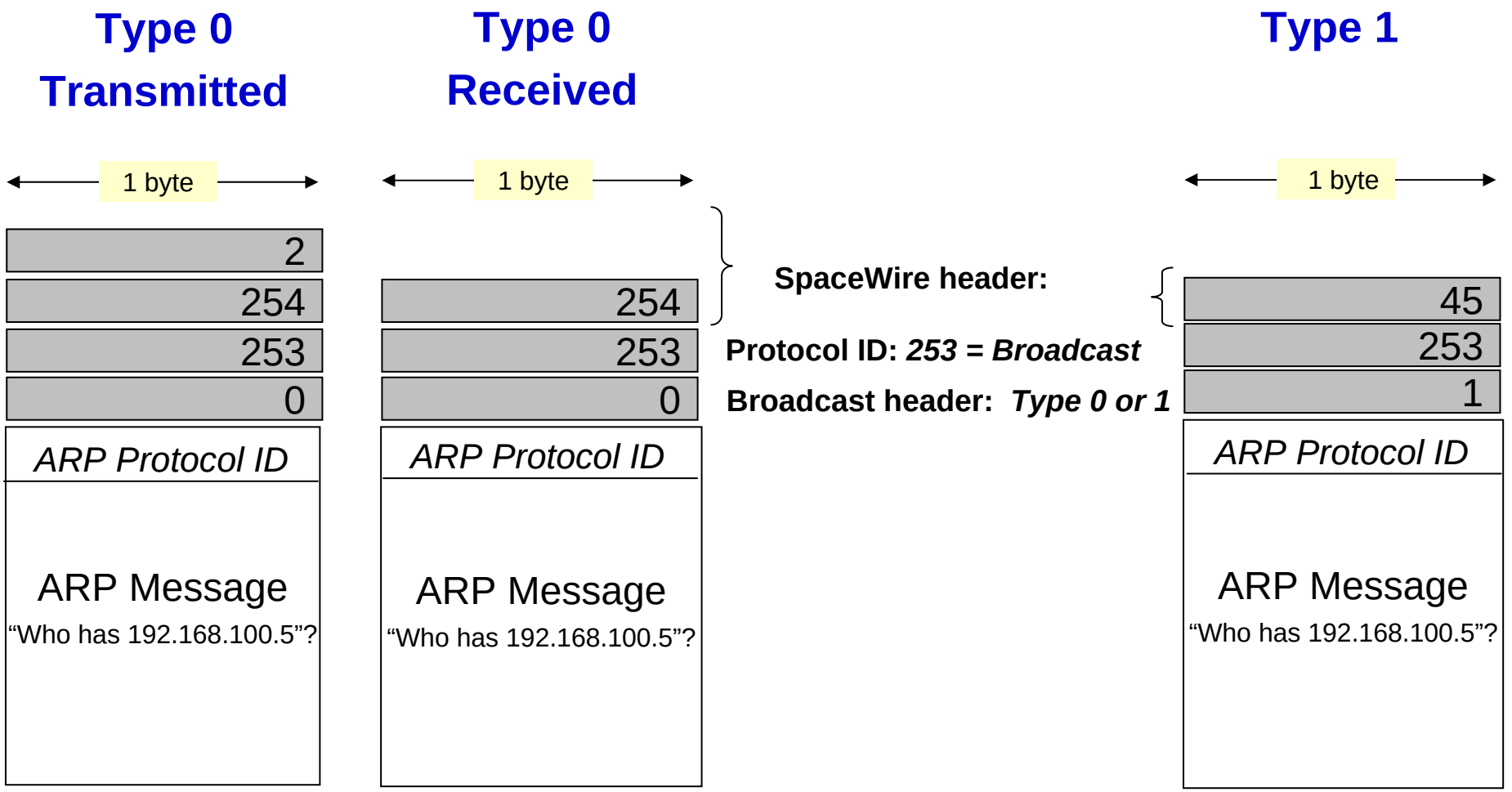
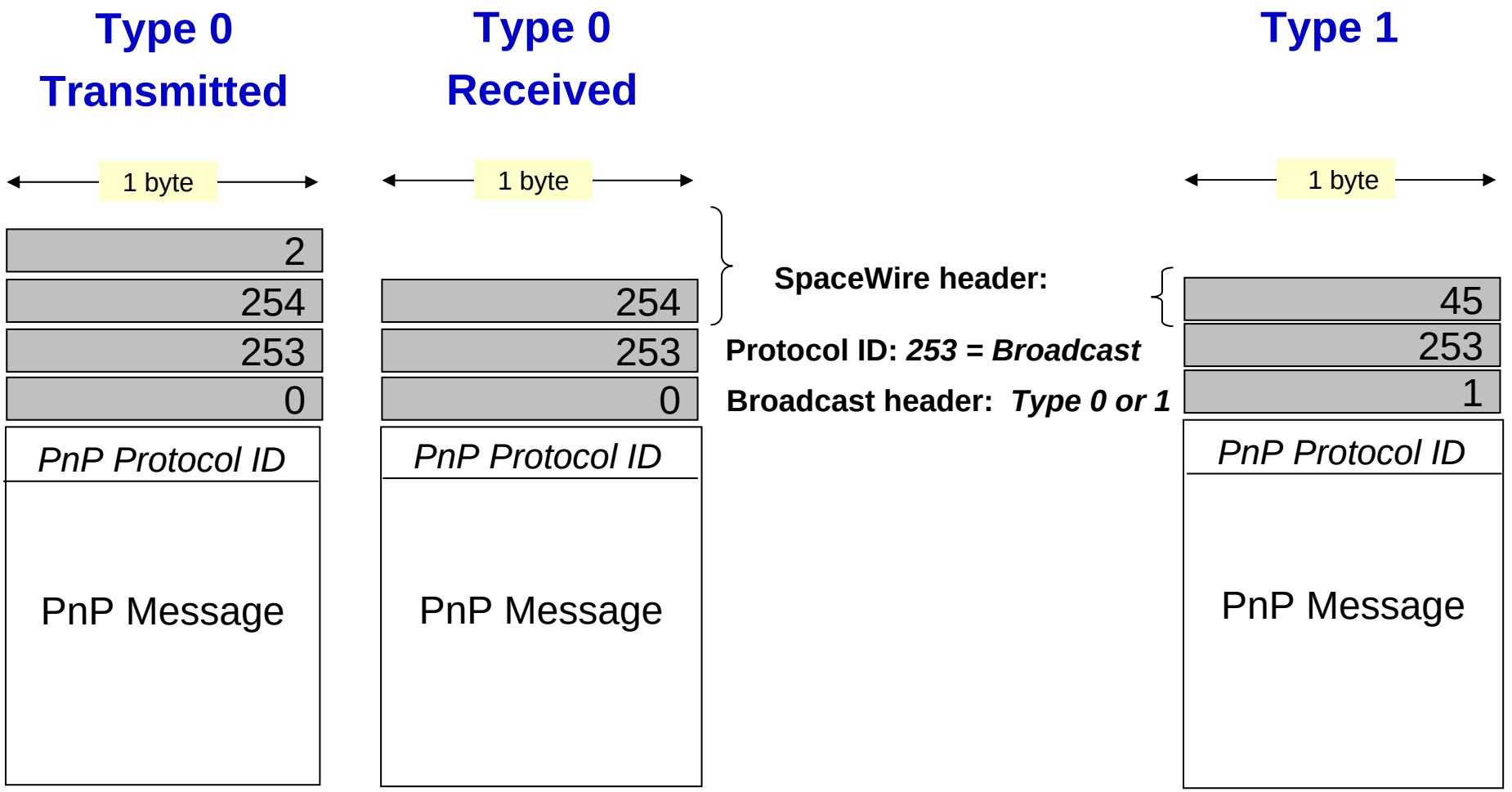
Packet Formats



Packet Formats – ARP Example



Packet Formats – PnP Example



Broadcast Server Configuration

- General nodes
  - No configuration
- Broadcast Server nodes
  - List of Broadcast Servers and path to each.
  - It own port number on the local router

    (not needed if PnP discovery or protocol extension)
- Routers
  - NULL entry for logical address 254

    (not needed if PnP discovery)

Unique Hardware Address

Necessary for ARP, not for broadcast.

Problem

- Hardware address must be unique across the LAN
- But … SpW interfaces do not have a unique pre-assigned hardware addresses and logical address are unique only within a region.

Solution

- Assign 1-byte Region ID
- Hardware address is <RegionID><Logical Address>
- 2-byte address

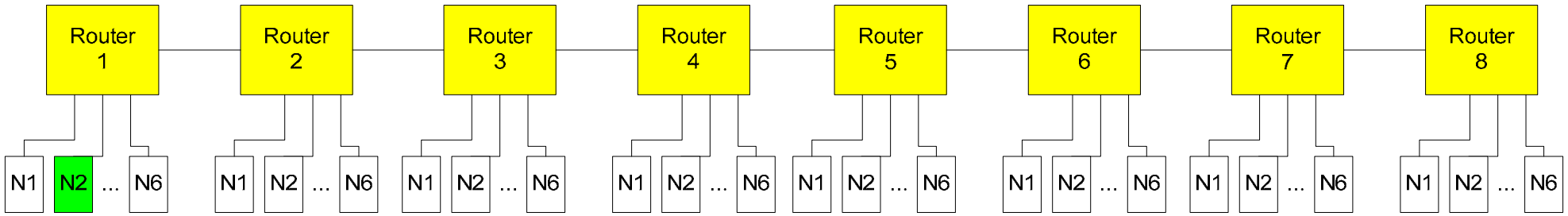
Region ID never appears in SpW header; it is used only within driver software.

Performance Evaluation

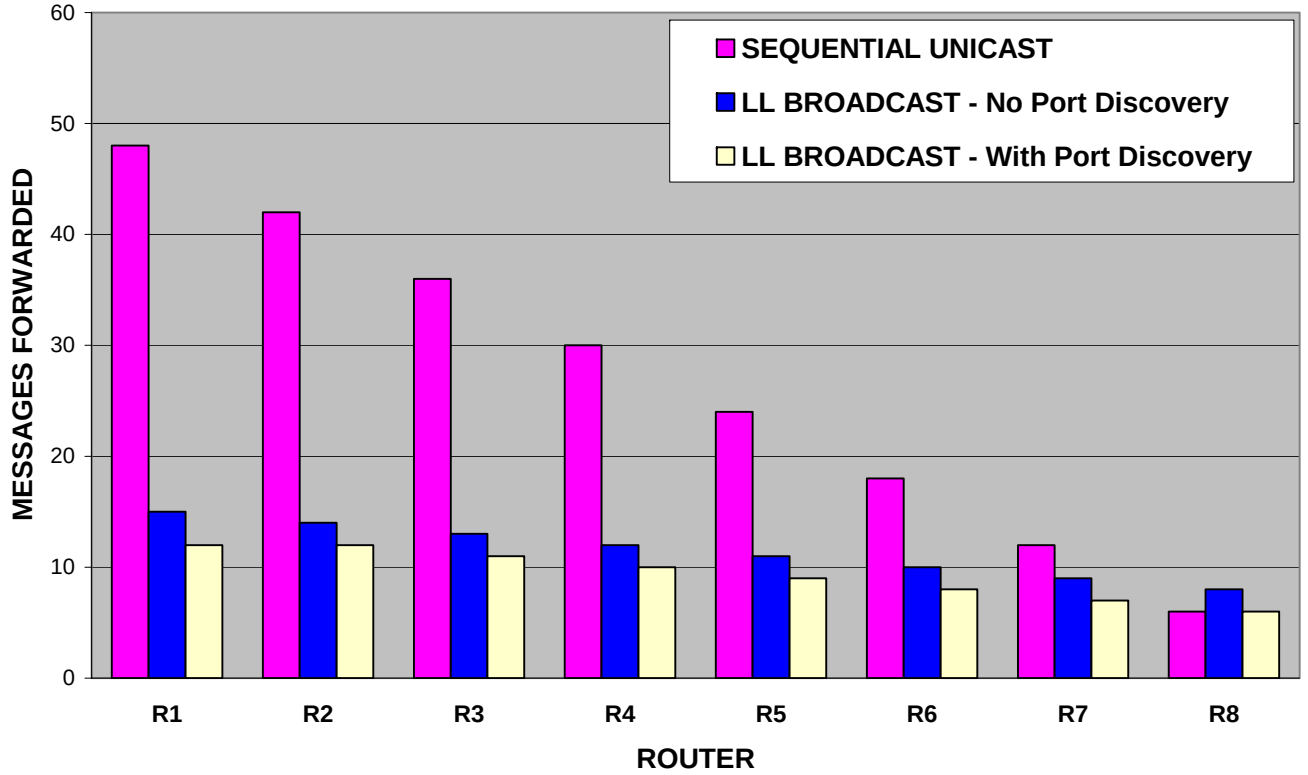
- Metrics
  - Traffic distribution across routers
  - Router load
  - Broadcast latency (time to complete)

- Evaluation Methods
  - Analytical Analysis
  - Simulation

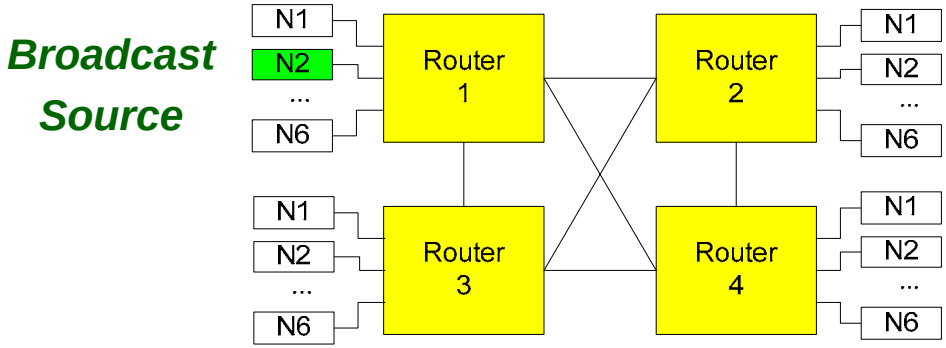
Traffic Distribution: Linear

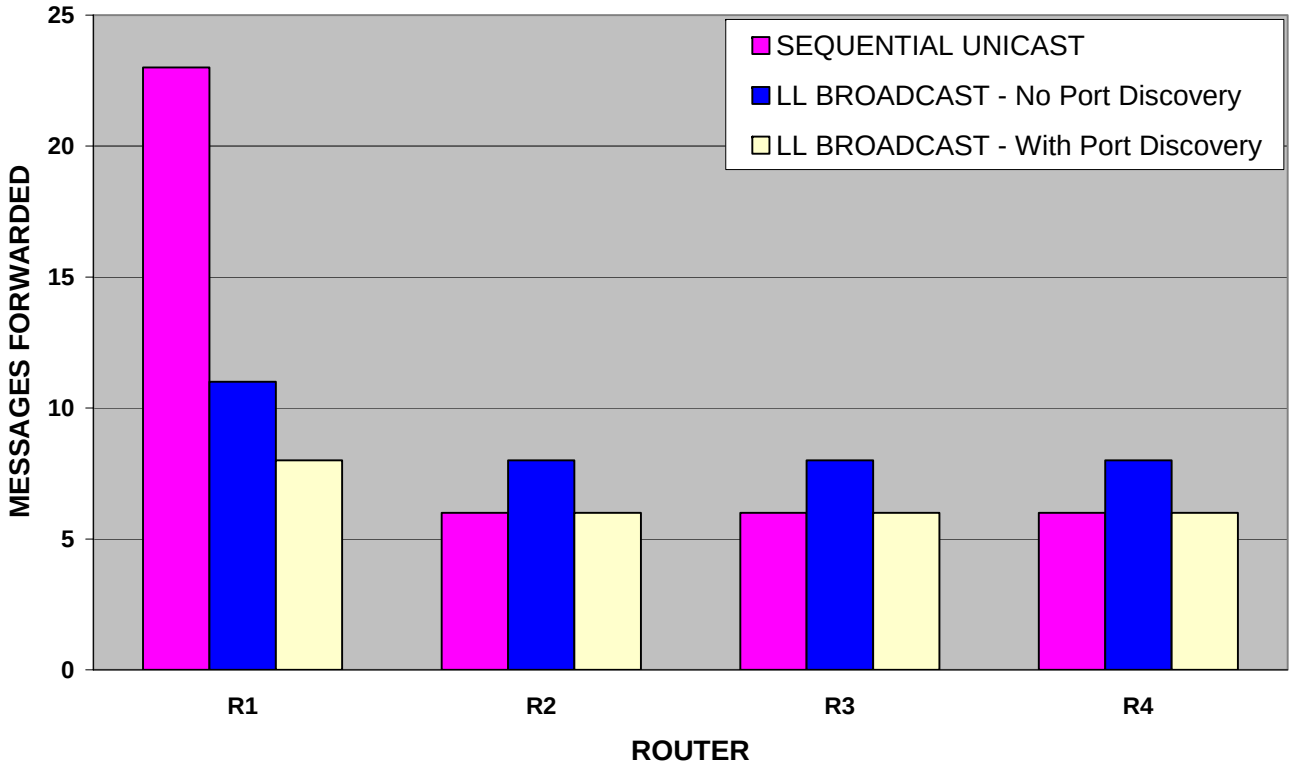


Broadcast Source

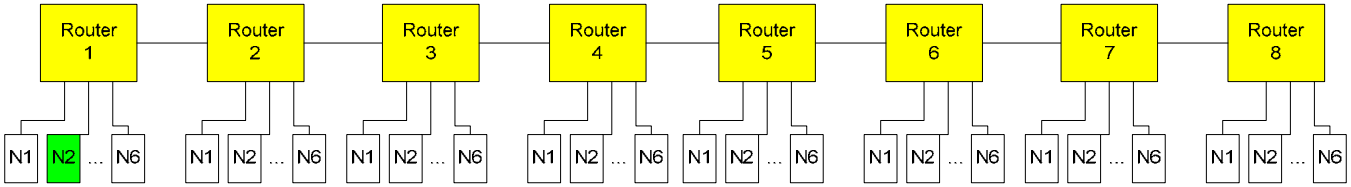


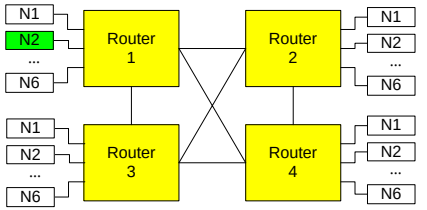
Traffic Distribution: Mesh

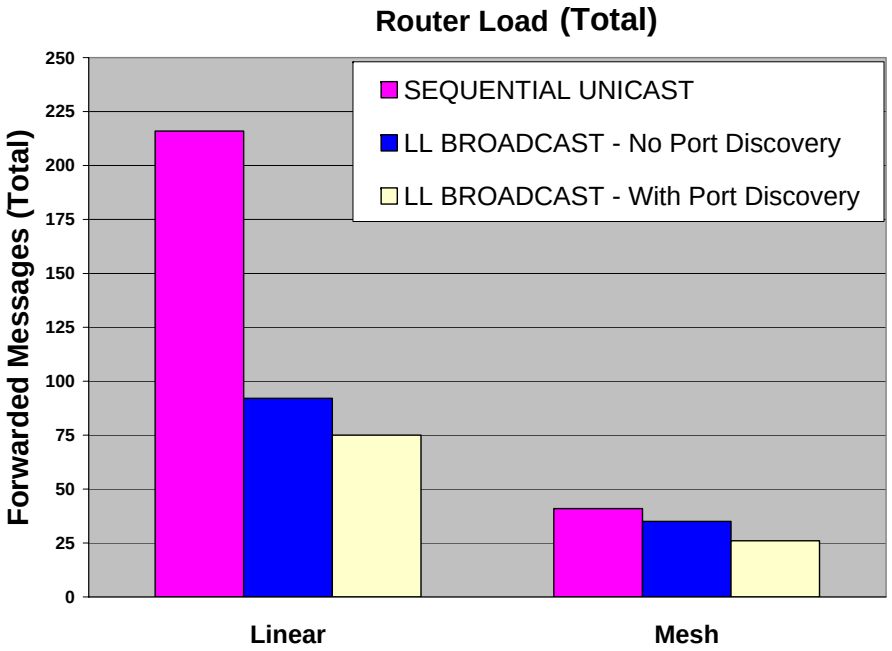


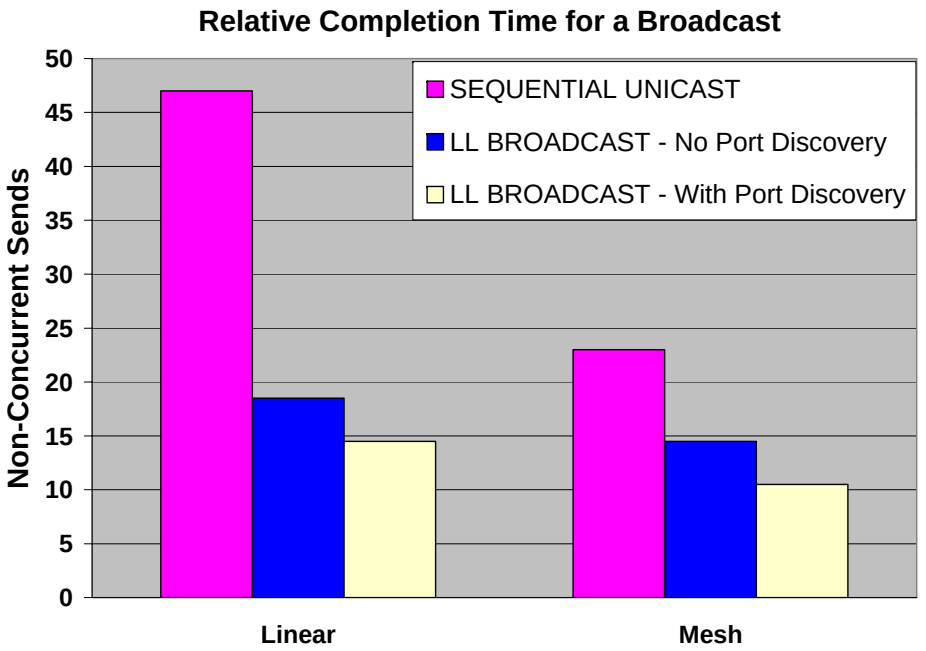


Router Load & Broadcast Latency









Relationship to PnP

- **Typically different purposes**
  - **Broadcast discovers shared services on distributed network: DHCP, FTP, TFPT, HTTP, …**
  - **PnP historically for dedicated peripheral devices (e.g. USB)**
  - **Data source / data sink model?**

- **Can PnP be used in broadcast?**

  PnP information on which ports are connected to nodes, to other routers, or not connected would improve performance.

- **Can broadcast be used in PnP?**
  - **Resource discovery by broadcast queries is alternative to central data manager at known address (e.g., SDM xTEDS).**
  - **Efficient notification method, but may be chicken and egg problem.**

Summary

- Simple & efficient
- Confined to network driver
- Can be used by any upper layer protocol (IPv4, IPv6, SCPS) or directly by application.
- Prototype implementation nearing completion
  - Linux network driver for SwRI cPCI SpW board.
  - Testbed: 2 StarDundee routers, 3 SwRI boards, 1 4Links board.
- Protocol specification document and broadcast function API will be available.