Case Study: Designing a Wireless Routing Protocol

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Designing a Wireless Routing Protocol

Objective: QualNet used to support:

- **Office of Naval Research advanced military communications, e.g.,:**
  - **Intra Battle Group Wireless Networking (IBGWN)**

- **Faster and less costly integration of IBGWN into larger DoD Internet Protocol (IP) networks, e.g.,:**
  - **Automated Digital Networking System (ADNS)**

- **Model the IBGWN VRC-99 line-of-sight (LOS) radio, which is capable of IP routing**

- **Simulate potential Layer 2 and Layer 3 routing protocols before they are implemented in any radio**

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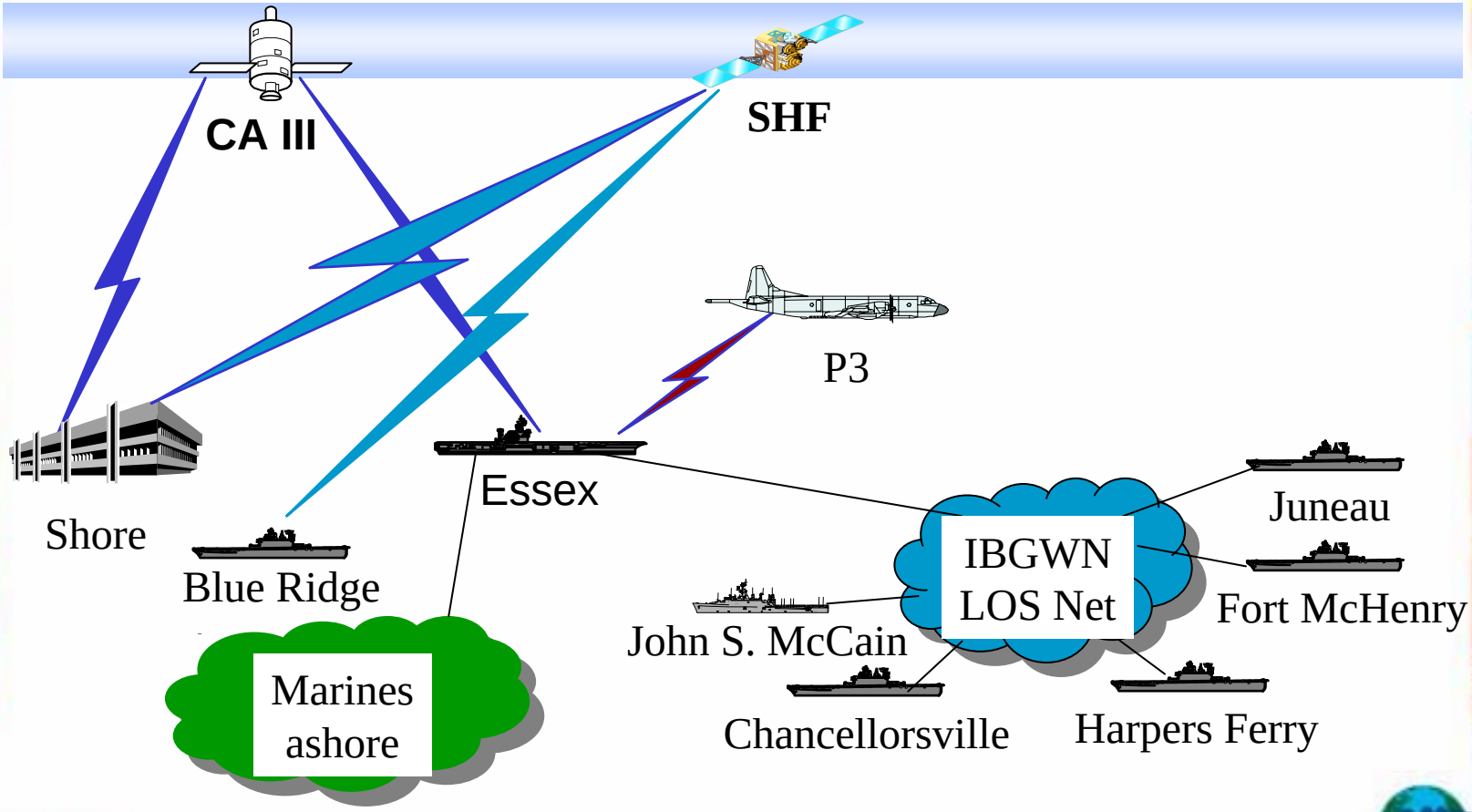

Note: Only part of the actual networks is shown

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Problem:

- **Mobility, combined with limited radio range, means LOS radios don't always fulfill the IP subnet model**

- **The RFC 1937 definition of the IP subnet model is: "Hosts with a common subnet address prefix are assumed to be attached to a common link (subnetwork), and thus communicate with each other directly, without any routers"**

RFC 1937, Y. Rekhter, D. Kandlur, "Local/Remote Forwarding Decision in Switched Data Link Subnetworks," May 1996.

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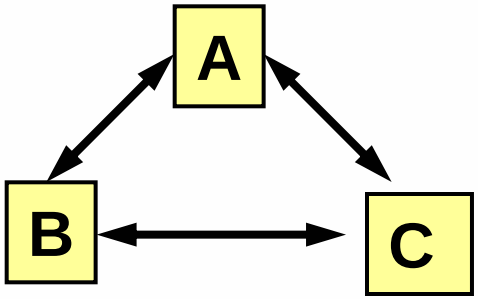
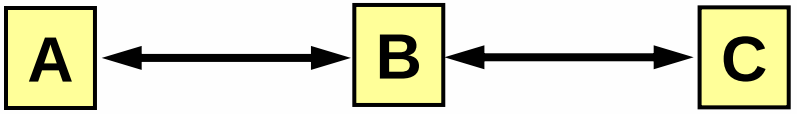
This … Can Become ... This





Fulfills IP Subnet model, no relay needed

Does not fulfill the IP Subnet model, relay is needed at B

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Proposed Solution:

- **A transparent relay protocol that allows the radios to appear to implement the standard IP Subnet model**

- **Each radio used periodic, unreliable flooding of the topology, and the Dijkstra Shortest Path algorithm, in order to determine whether or not to relay a given packet**

- **Multicast was implemented as a link layer broadcast: The Dijkstra/Prim Minimum Spanning Tree, routed at the multicast source was used to determine whether or not to relay**

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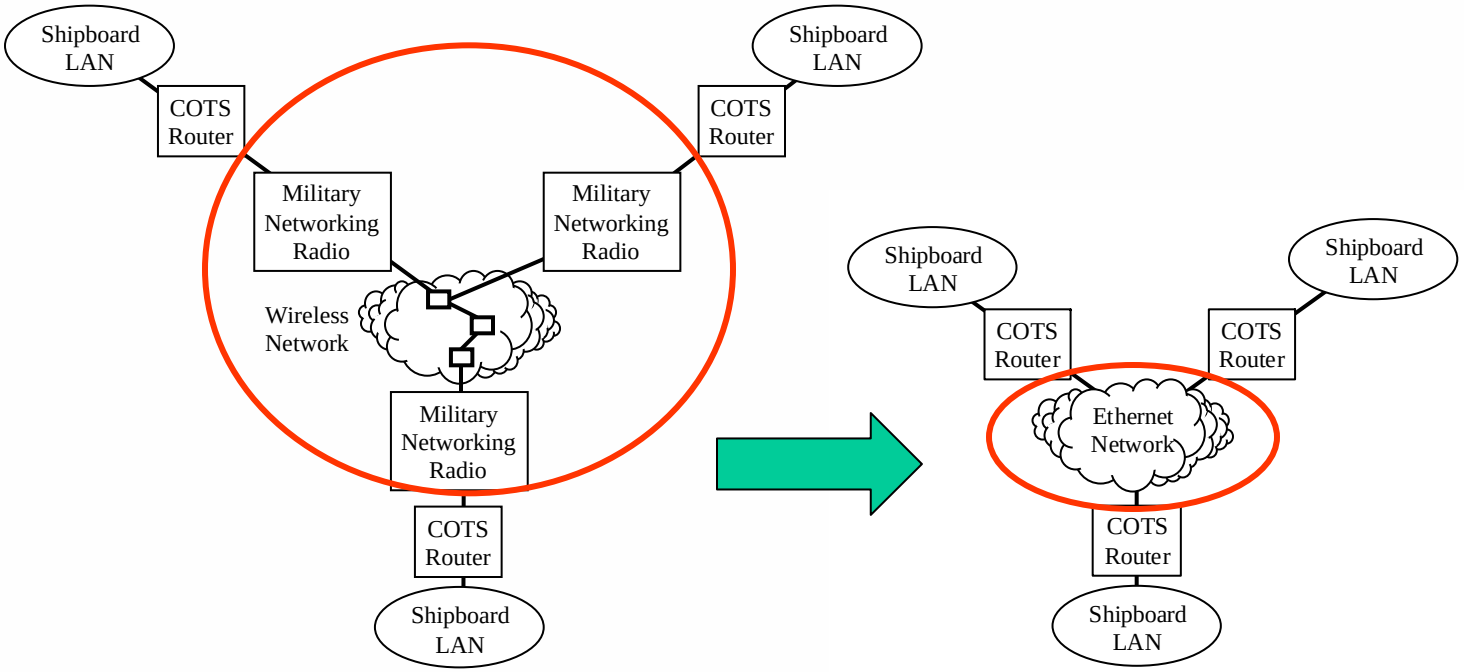

Assumed Physical Connectivity

Desired Logical Connectivity

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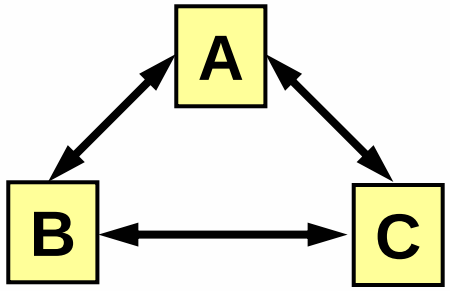
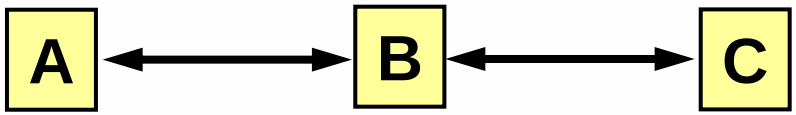


In this case, the routing protocol determines that every radio can reach every other radio directly, so no radio relays packets

TDMA is used to share a single frequency



In this case, the routing protocol determines that relaying is required

Radio B relays packets from A and C on the same frequency that they were received on

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Results:

- **Convergence Time: In most mobility scenarios, routes were established in less than a minute**

- **In the worst case, the network took 100 seconds to begin routing packets**

- **Bandwidth Consumption: As the number of nodes varied from 4 to 16, and the Update Interval varied from 1 to 10 seconds, bandwidth consumption varied from 500 to 5000 bits per second per node**

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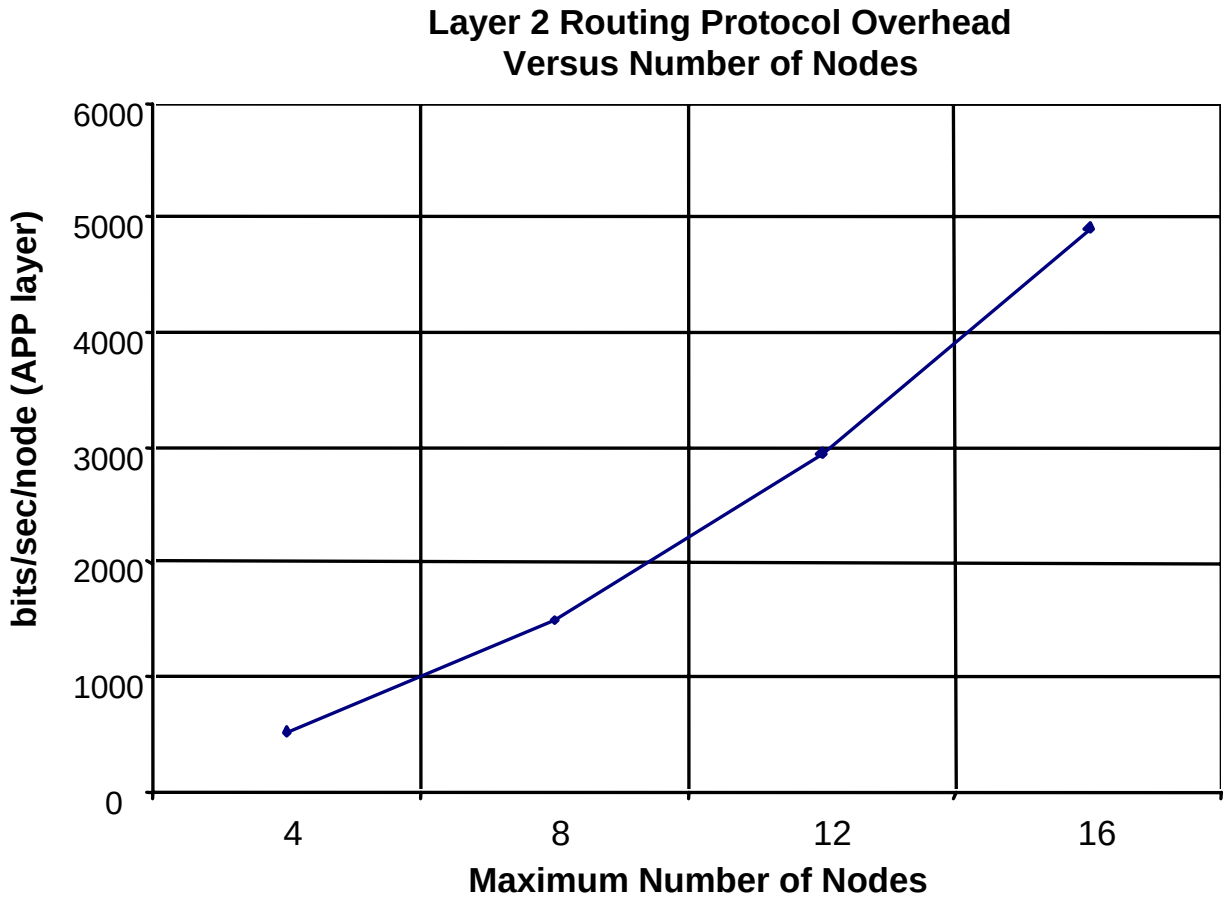

The increase in the size of the connectivity matrix accounted for most of the increase in overhead

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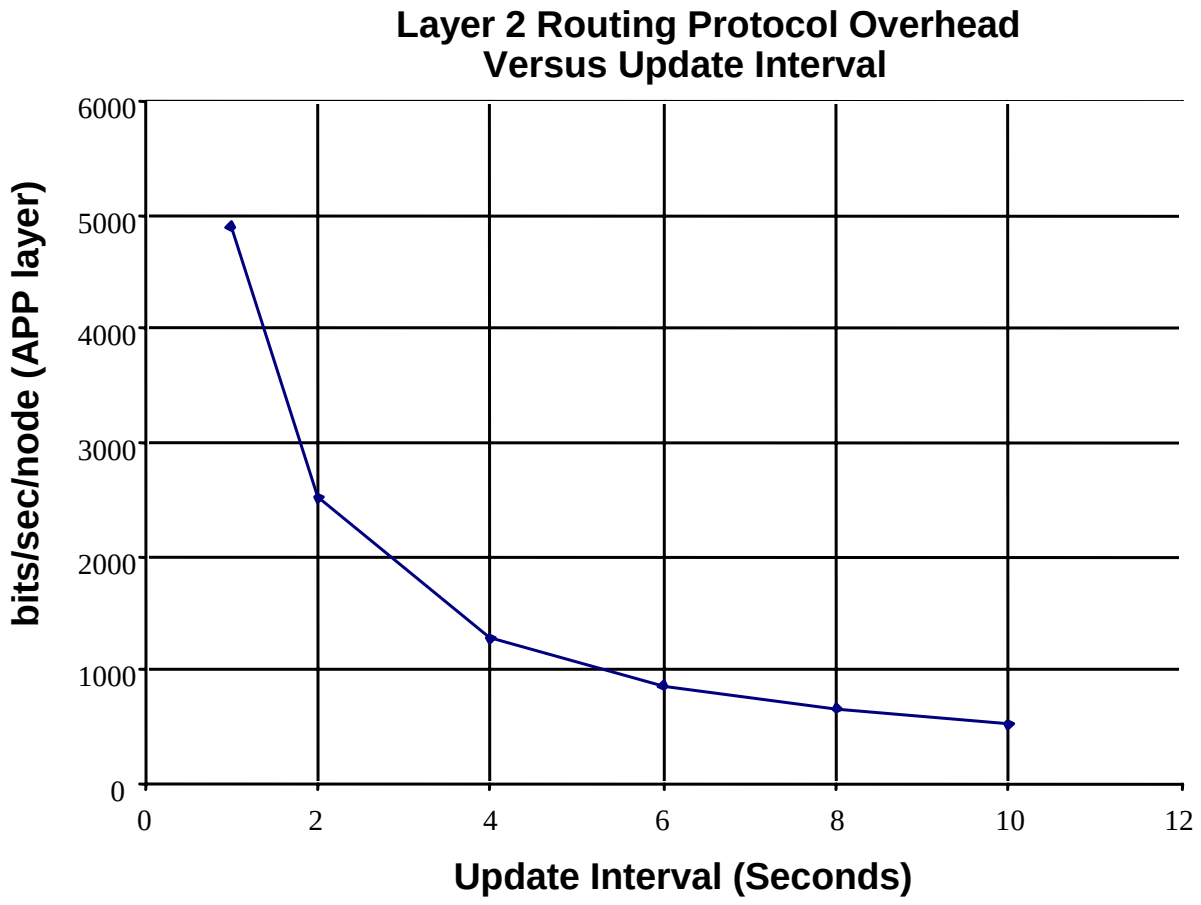

The increase in overhead is linear with the inverse of update interval (frequency)

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Conclusions:

- Emulating a standard IP Subnet makes it is possible to use any vendor's routing equipment, and a wide variety of routing protocols, e.g., OSPF, EIGRP, IS-IS, and BGP

- This, in turn, makes it faster and less costly to integrate the LOS network into larger IP networks

- Simulation makes it faster and less costly to develop the LOS routing protocols that can emulate IP Subnets

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Any Questions?

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