



# Internet of Things Workshop *The “mesh--under” versus “route over” debate in IP Smart Objects Networks*

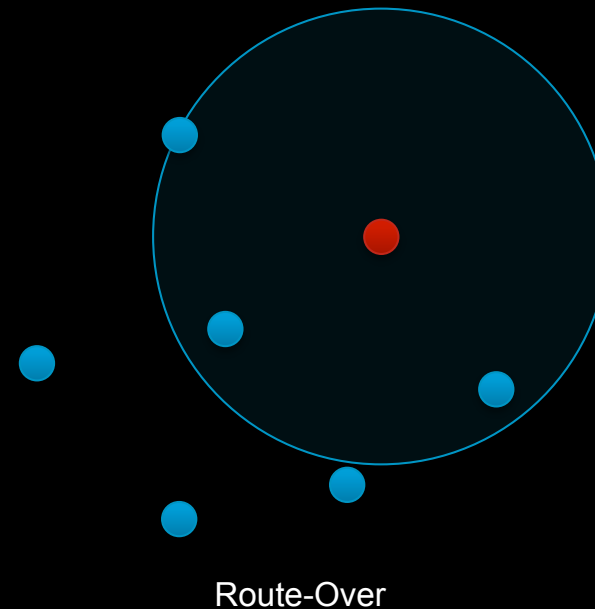
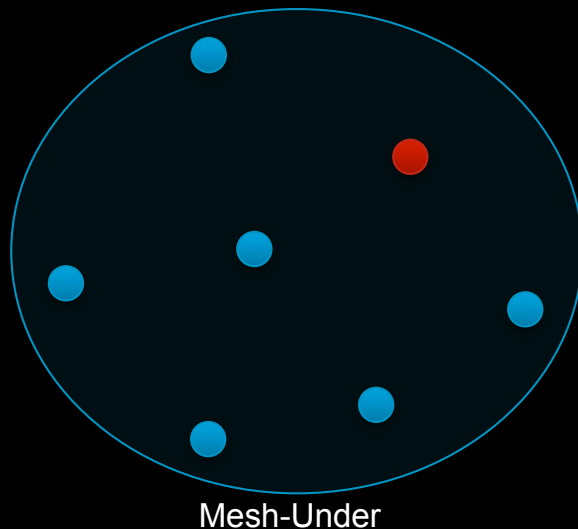
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# Mesh-Under vs. Route-Over

- Mesh-under places routing functions at the link layer
  - In many cases, to maintain the Ethernet abstraction
  - Single broadcast domain, deterministic link characteristics
- Route-over places *all* routing functions at IP layer
  - Every PHY hop appears as an IP hop



# Mesh-Under and IPv6 ND

- IPv6 ND assumes deterministic link characteristics
- Neighbor Unreachability Detection
  - Must operate over multiple LLN link hops
  - Communication latency and reliability can vary greatly
  - What timeout to use?
- Default Router Selection
  - Expose link-layer path cost when selecting a router?
  - How to utilize different path costs?
  - Multi-layer recovery issues

# Mesh-Under and Link-Local Scope

- Link-Local scope spans the entire LLN
  - All devices in a LLN appear as an IP neighbor
- Any IP traffic can invoke costly operations
  - Any link-local traffic may invoke L2 routing functions
  - Any link-local multicast may span the entire LLN
- Cannot build IP protocols that:
  - Limit communication to immediate neighbor
  - Discover and utilize link topology
  - Build effective overlays for in-network processing

# *Routing: at which layer?*

- Lots of interesting research initiatives in WSNs
  - Focus primarily on algorithms, not on architecture
  - Most directly use MAC addresses – L2 “routing” (mesh-under)
- Support of multiple PHY/MAC is a MUST, *one of the key advantages of IP layered architecture*
  - IEEE 802.15.4, Low-Power WiFi, PLC (number of flavors),...
- A layered network architecture that supports multiple PHY/MAC technologies?

***The Internet Protocol, of course!***

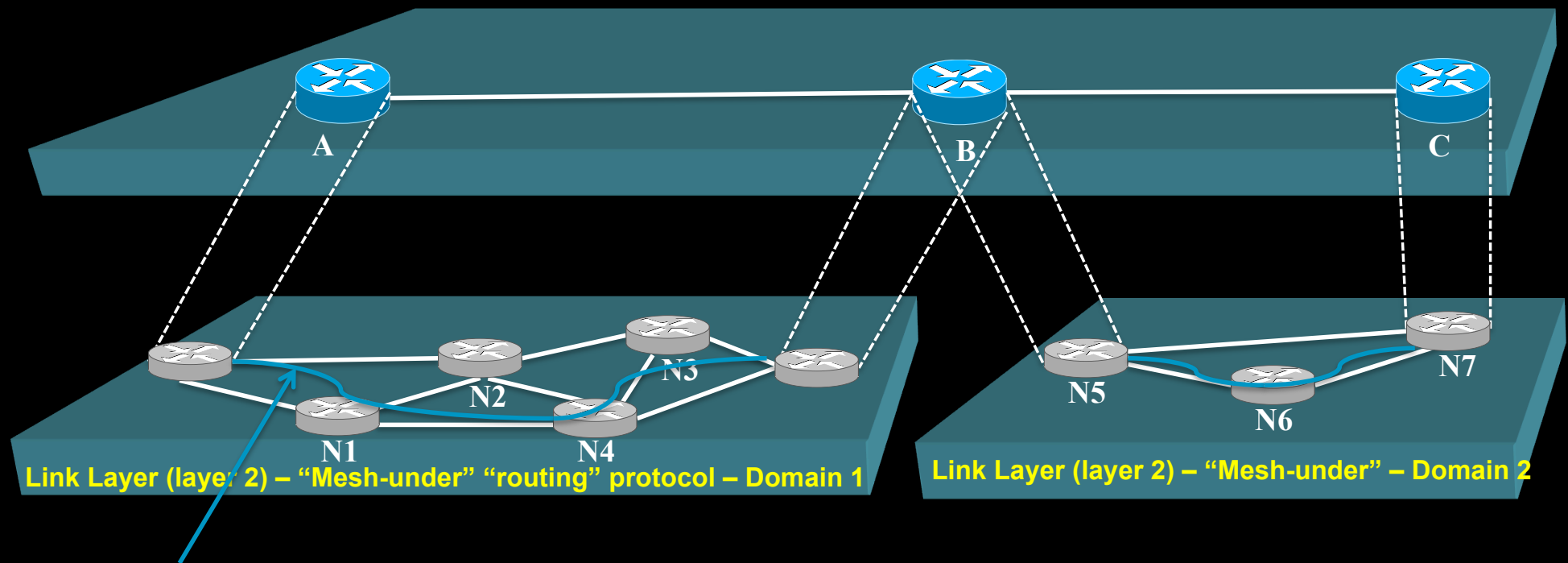
# *The shortcoming of multi-layer routing*

*Haven't we learned from the past ? Remember IP over ATM ?*

- IP layer with no visibility on the layer 2 path characteristic
- Issues when not using the same metrics, objective functions, filters/dampening, ...
- Makes “optimal” or “efficient” routing very difficult
- Layer 2 path (IP links) change because of layer 2 rerouting (failure or reoptimization) lead to IP kink metric changes.  
*How is this updated ?*
- There is still a need for an abstraction layer model but for Point to Point layer 2 links => Routing Metrics

# The shortcoming of multi-layer routing Cont'

*Lack of actual path characteristics, consistency between routing metrics/OF/..., inability to compute optimal end-to-end path, ...*



**A-N1-N4-N3-B is the link layer path computed by the “mesh-under” “routing” protocol operating at the link layer in domain 1**

# Combine “Mesh Under” and “Route Over”

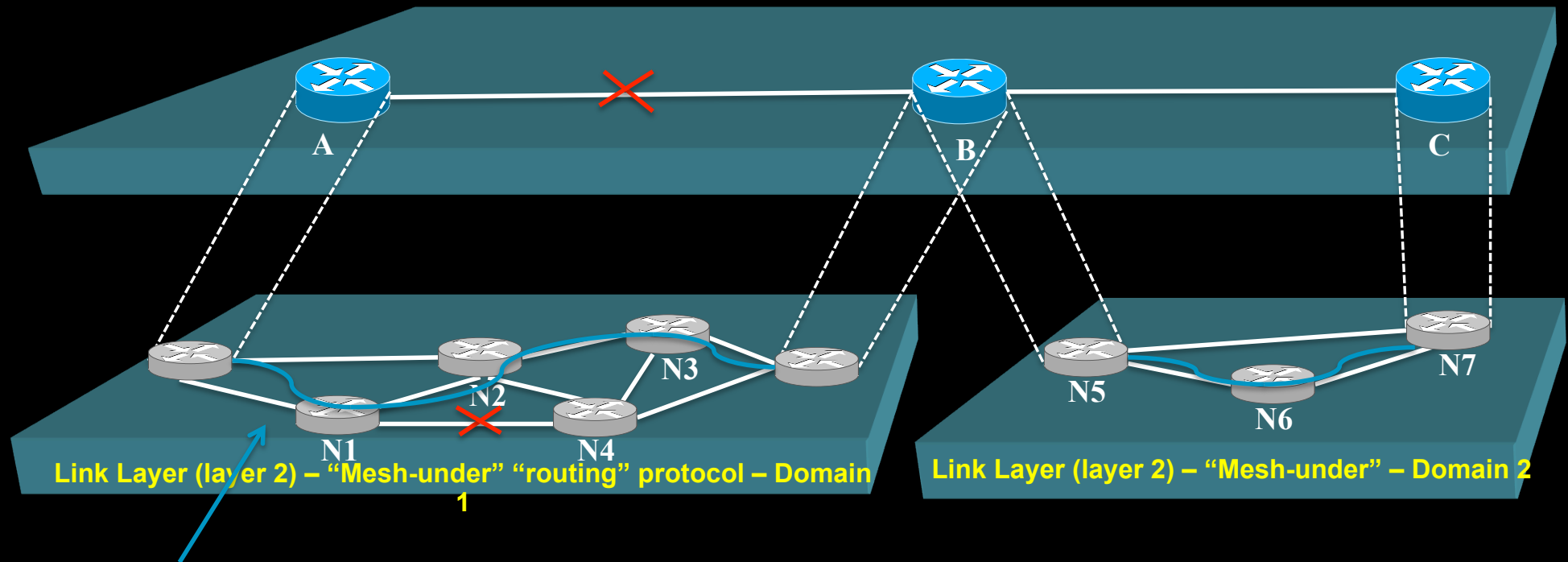
Another **major** challenge: **multi-layer recovery**

- Require a multi-layer recovery approach
- Current models are timer-based:
  - Needs to be conservative and most of the time bottom-up
  - Increased recovery time for failures non recoverable at layer 2
- Inter-layer collaborative approaches have been studied (e.g. IP over Optical) => definitively too complex for current Sensor Hardware



# The shortcoming of multi-layer routing

## Cont' => Multi-layer recovery



**A-N1-N2-N3-B is the new path computed by the "mesh-under" "routing" after the failure of the N1-N4 link**

# Conclusion

- See paper for more details (IETF draft to be submitted soon)
- Try to show the shortcomings of a mesh-under approach ...
- Support of route-over is a MUST and RPL is the only routing protocol standardized at the IETF
- Support of multi-layer routing in LLN:
  - Does not bring any value
  - Dramatically increase complexity (we have the experience !)
  - Number of shortcomings: lack of visibility and consistency across routing protocols, multi-layer recovery, ...
- We have a route-over solution specified at the IETF why adding any additional routing protocol ???

