

On Seamless Connectivity on Multi-Radio, Multi-Channel WMN

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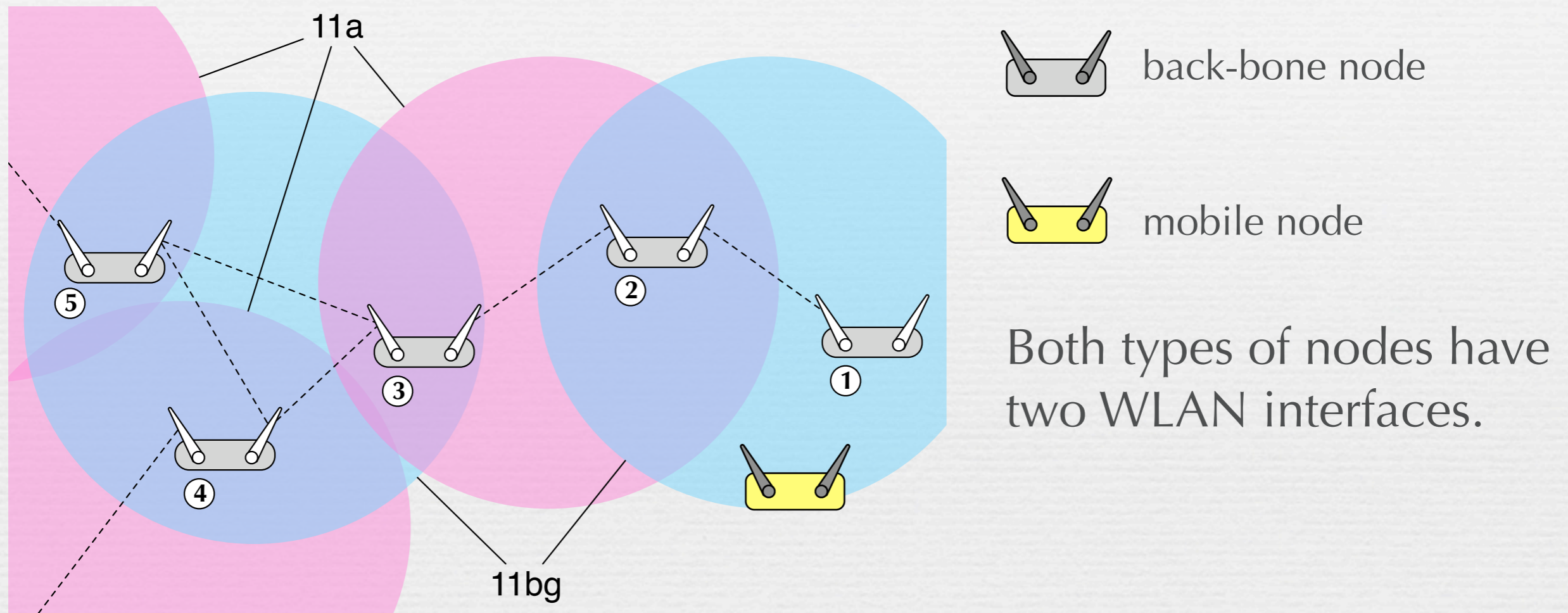
Outline

- **A WMN Architecture for Seamless Connectivity**
- **A Technique to Analyze the behaviors of WMNs**

Instant Networking

- Needs for *Instant Networking*
 - for rural and disaster-stricken areas
 - to support short-term conferences and search and rescue operations
- We adopted multi-radio, multi-channel wireless mesh networks (MM-WMNs) as the foundation of the research.

The Configuration of the WMN

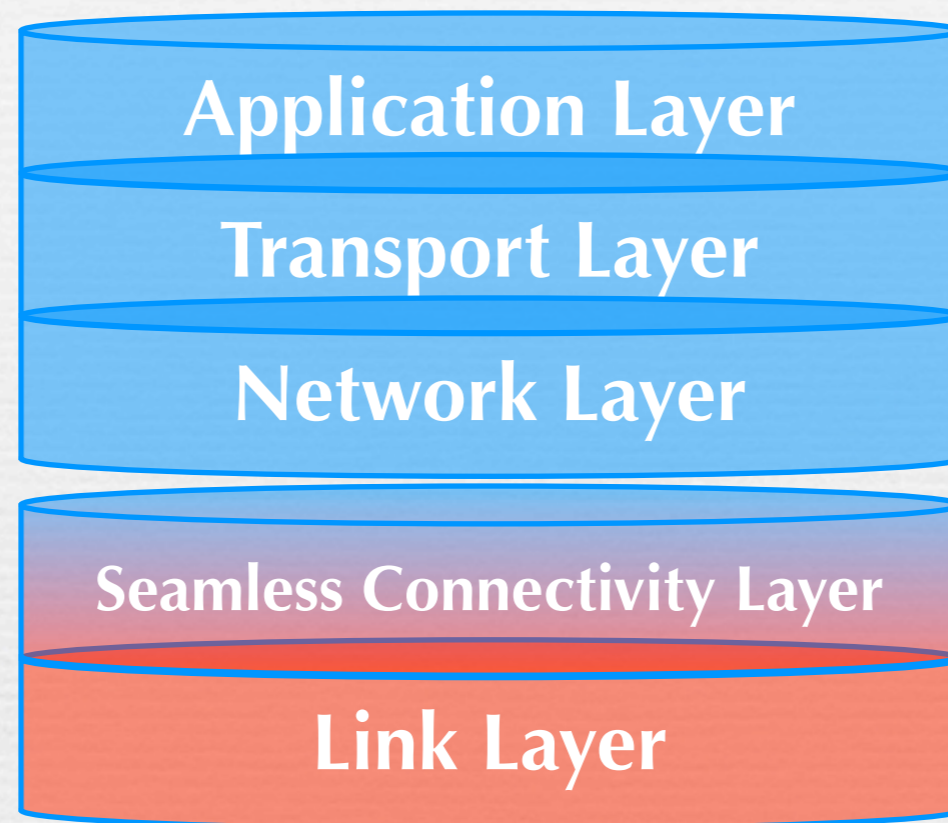


- We achieved high throughput and low latency because of reduced interference along with communication paths.

Issues

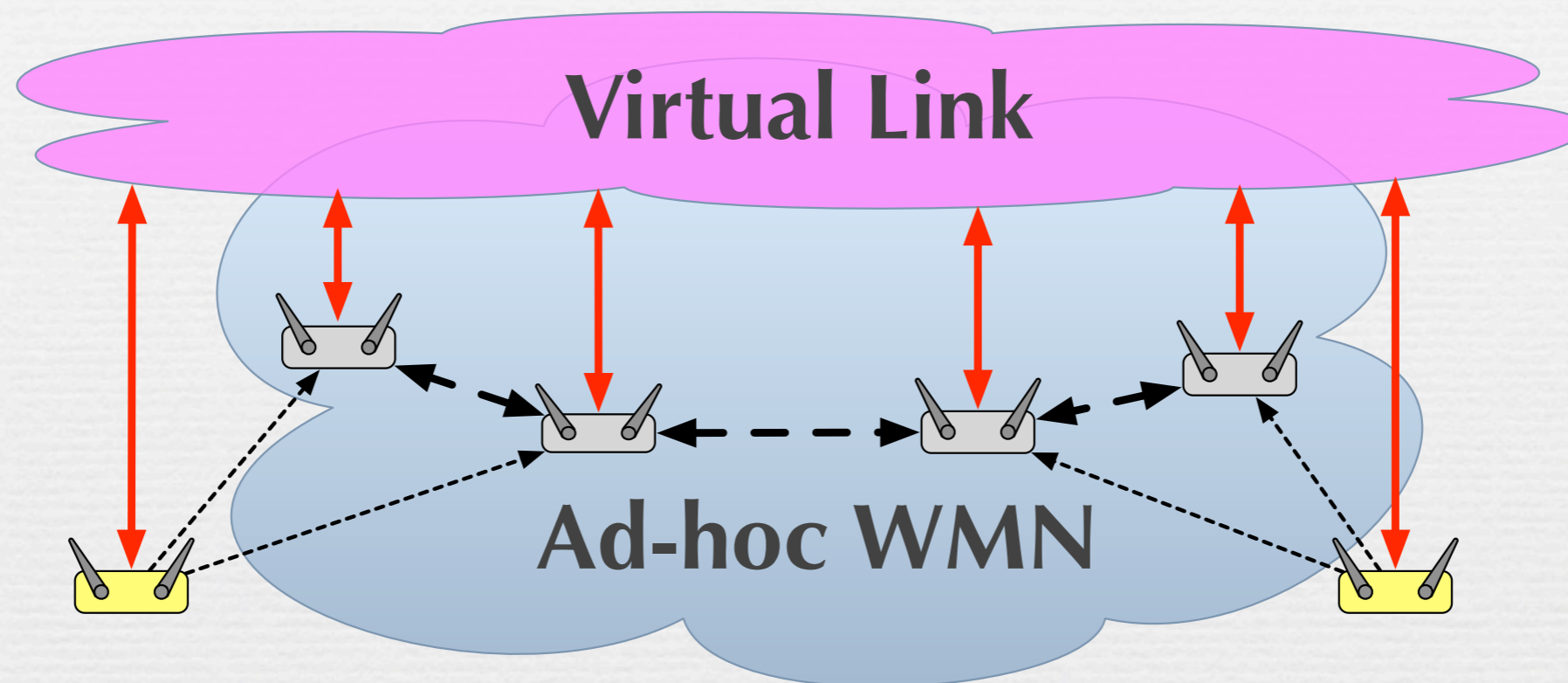
- We, however, had trouble in maintaining connectivity to mobile nodes because of multi-channelized communication media.
- A need for a mechanism to support seamless connectivity for mobile nodes.

An Architecture for Seamless Connectivity



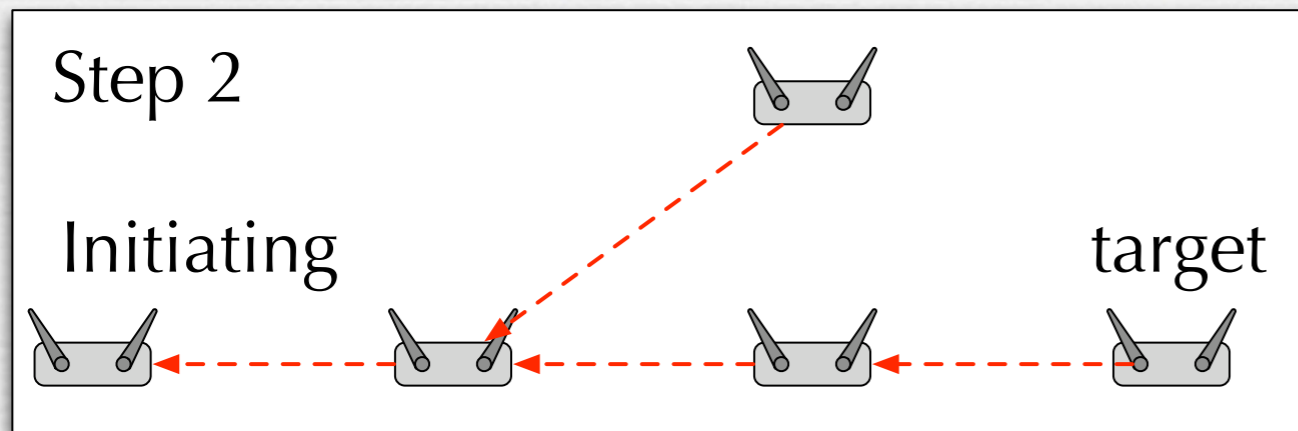
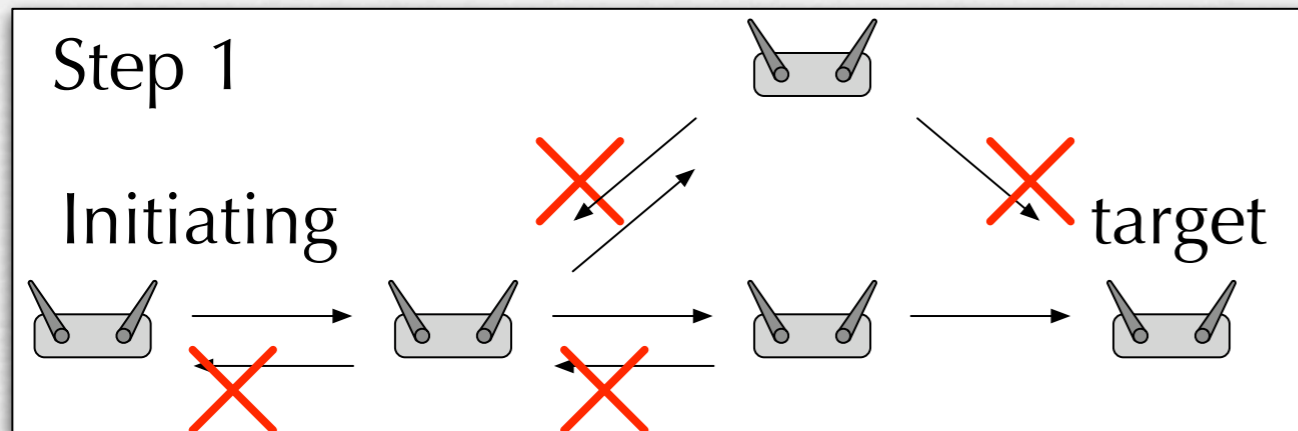
- We introduce the *Seamless Connectivity Layer* between Link and Network Layer.

An Architecture for Seamless Connectivity



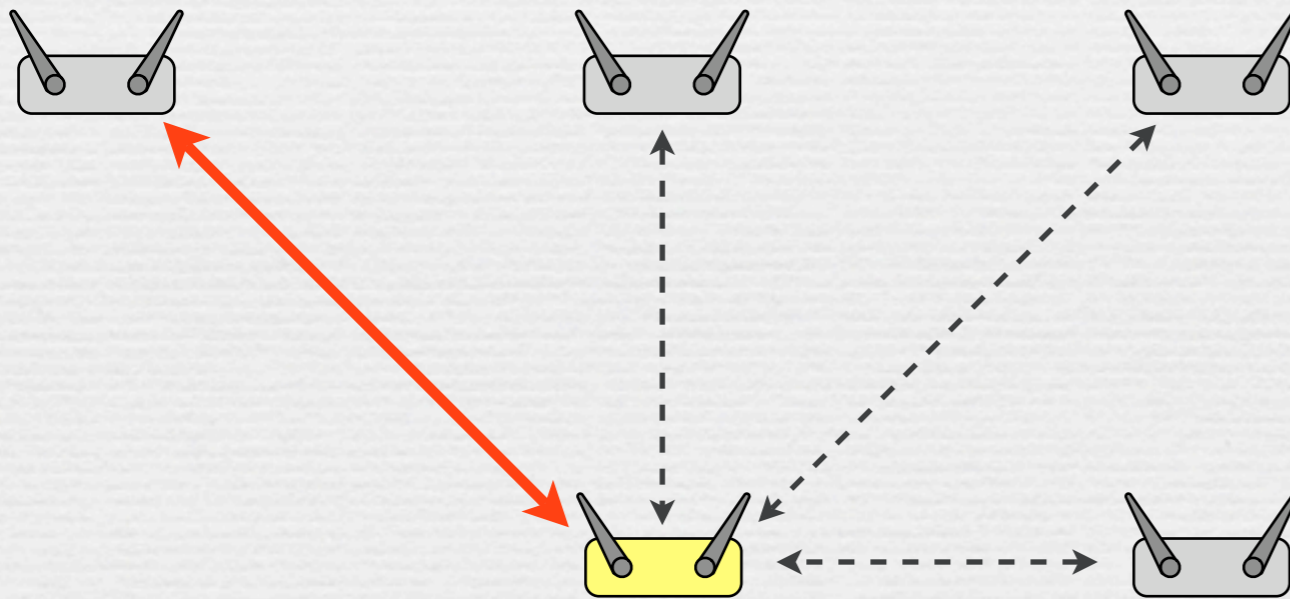
- The Seamless Connectivity Layer handles routing and hand-over and provides the view of Ethernet-like *Virtual Link* for all the nodes.

Routing in Virtual Link



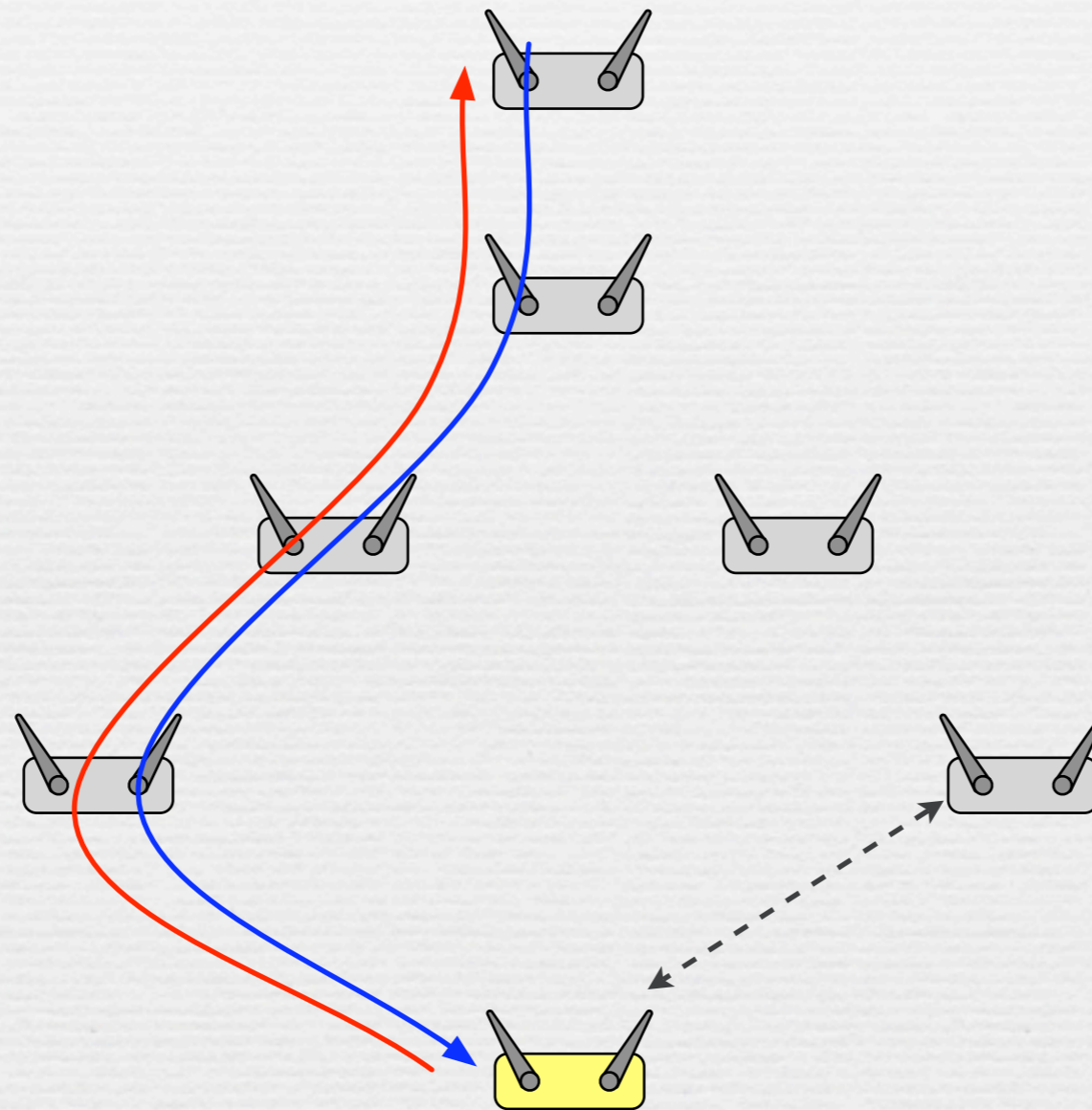
- Learning Switch with Duplicated Packet Detection(DPD)

Handover in Virtual Link

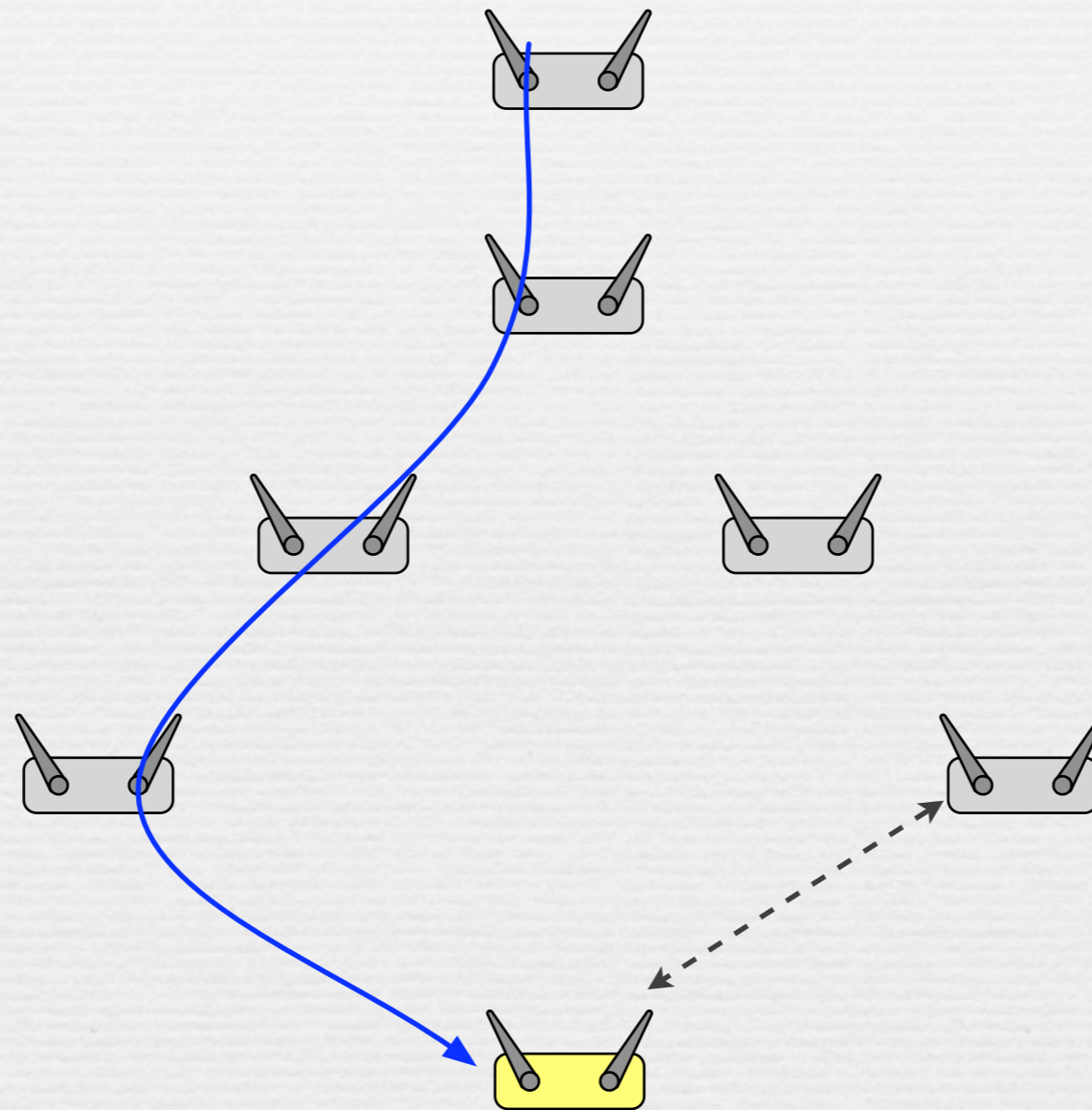


- This part will be presented in detail by Tadashi Yasumoto in the session on 14th.

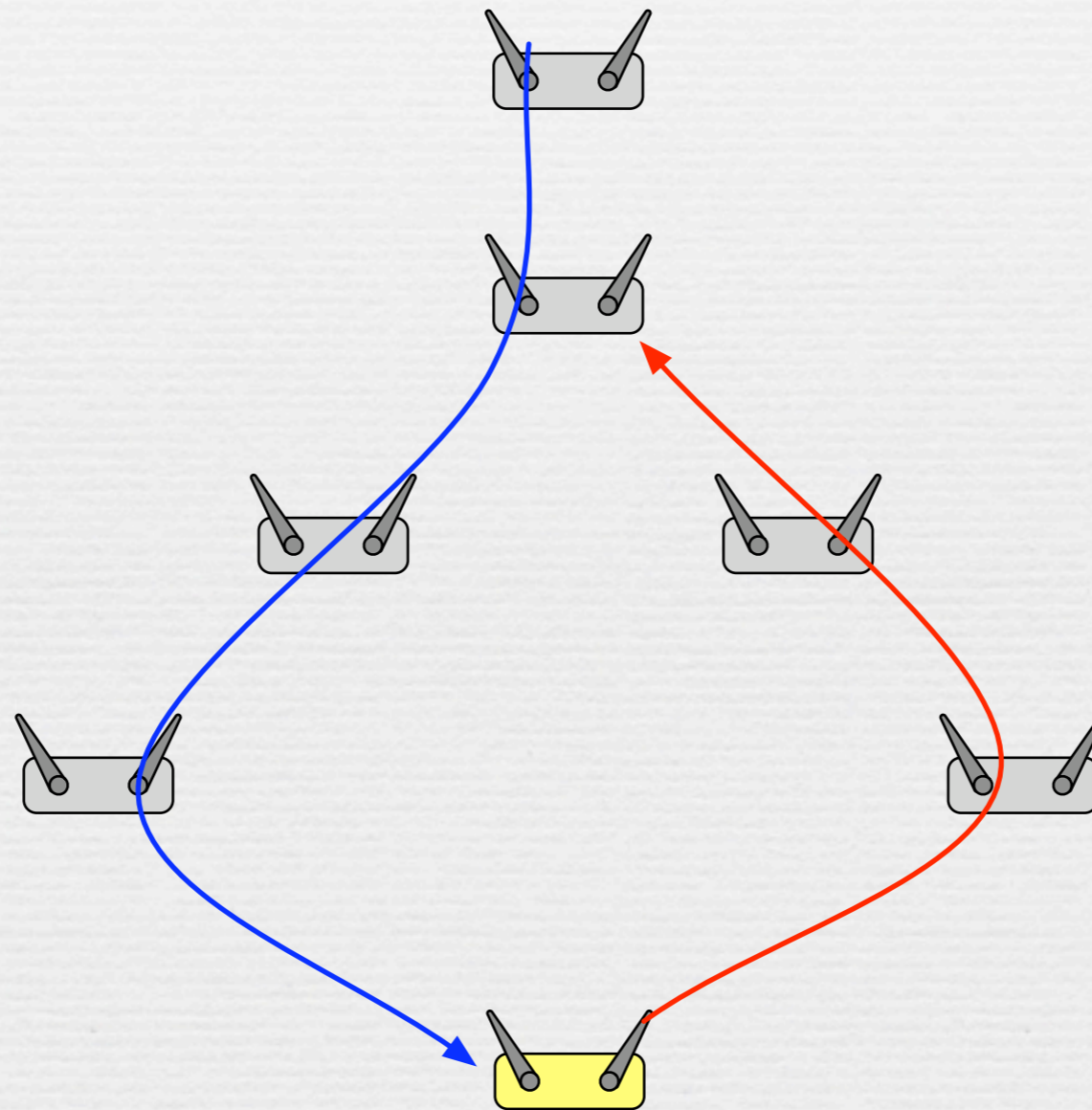
Routing and Hand-over Combined



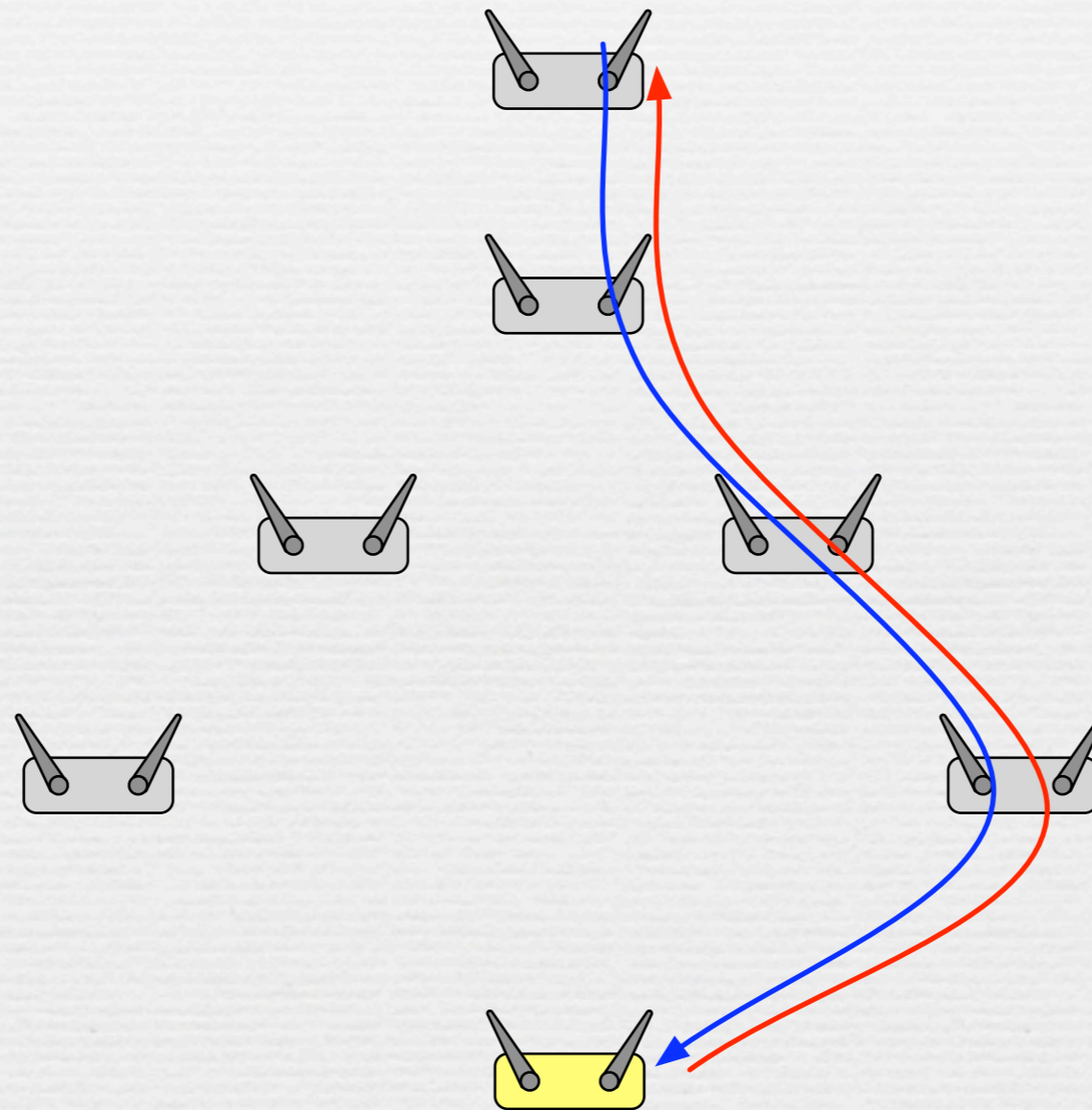
Routing and Hand-over Combined



Routing and Hand-over Combined



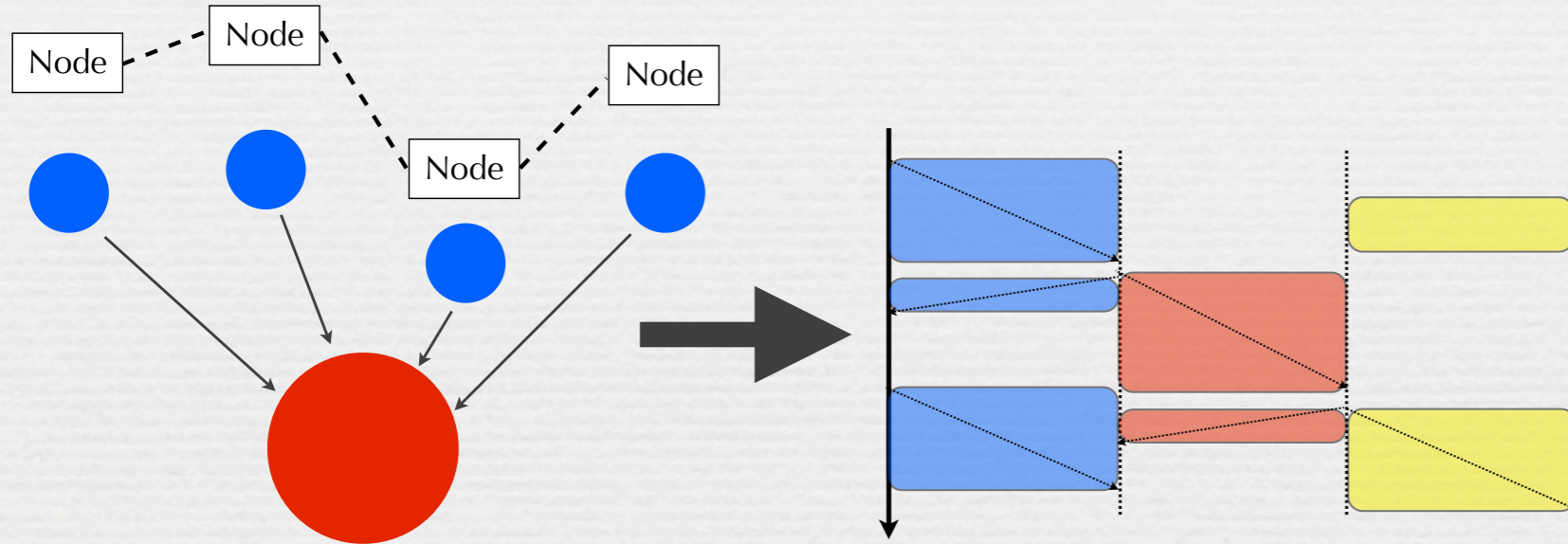
Routing and Hand-over Combined



Issues

- Although we saw the implementation working, we could not see
 - how many retransmissions happened during hand-over
 - how did it affect the behavior of higher layer protocols, such as TCP.
- This motivated us to work on a detailed analysis on the WMN behavior.

A Detailed Analysis on WMNs?



analyzing

- queuing delay
- interaction with TCP
- conflict graph on real WMN!

merge and synchronize
the packet traces
gathered by different
nodes.

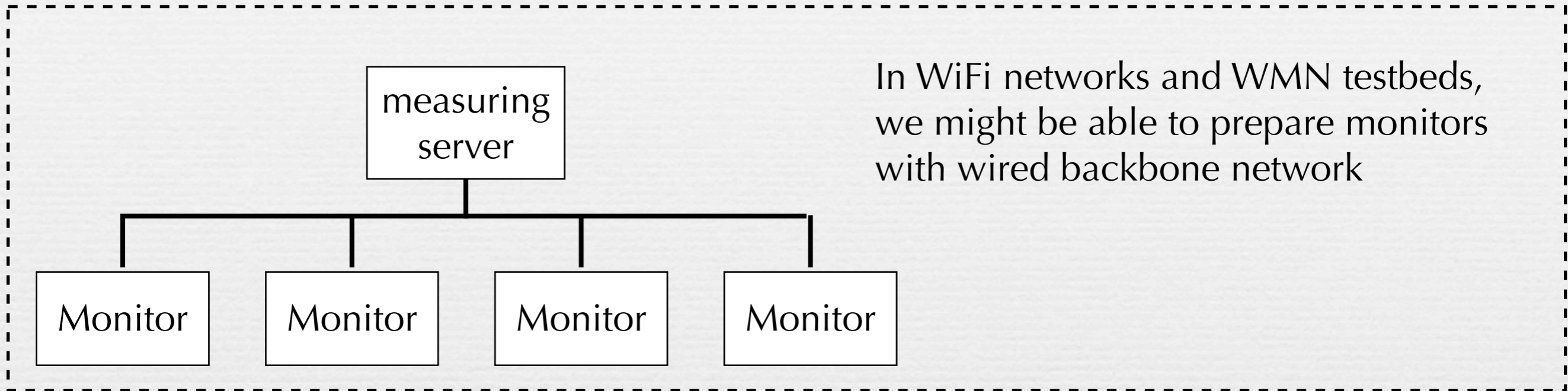
construct the packet trace
of the whole WMN.

Background

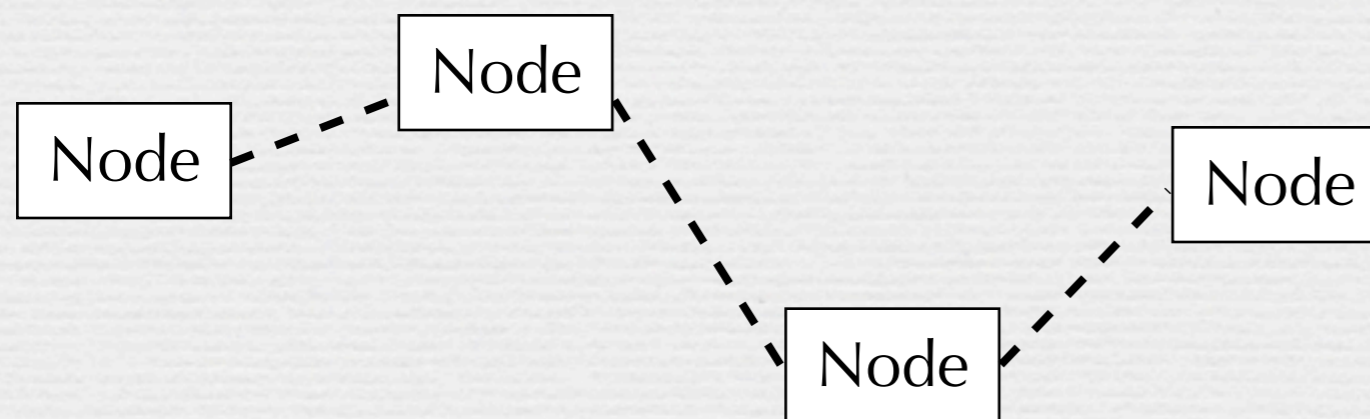
- For large WiFi networks
 - Jigsaw[Sigcomm 2006], Wit[Sigcomm 2006]
 - merging some traces at the precision of 20 micro seconds
 - under the assumption that there are monitors with a wired backbone network

This assumption is not acceptable in WMNs!!

Lack of Resources



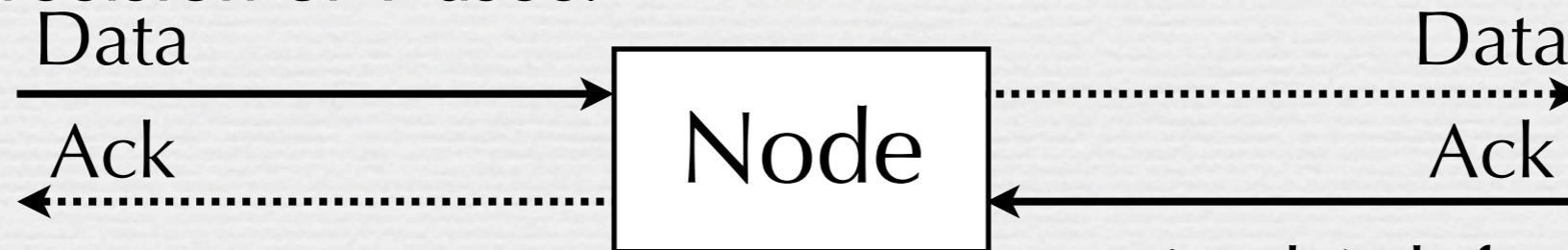
In WiFi networks and WMN testbeds, we might be able to prepare monitors with wired backbone network



It is difficult to conduct Time Synchronization and Retrieval of Packet Trace.

Limitation on Device Driver

Received Data frame is timestamped by the receiving NIC at the precision of 1 usec.



Ack is transmitted by the NIC and cannot be seen from Node.

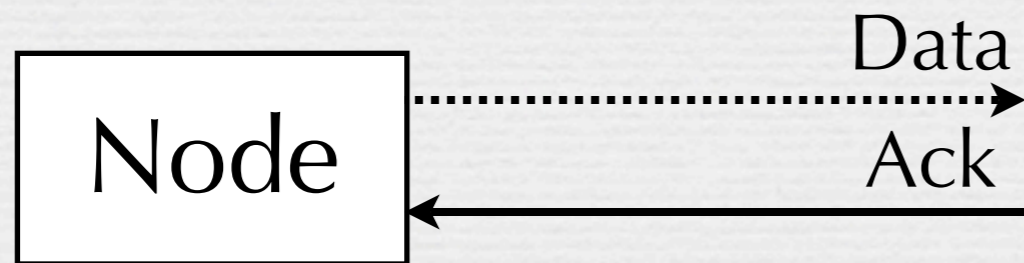
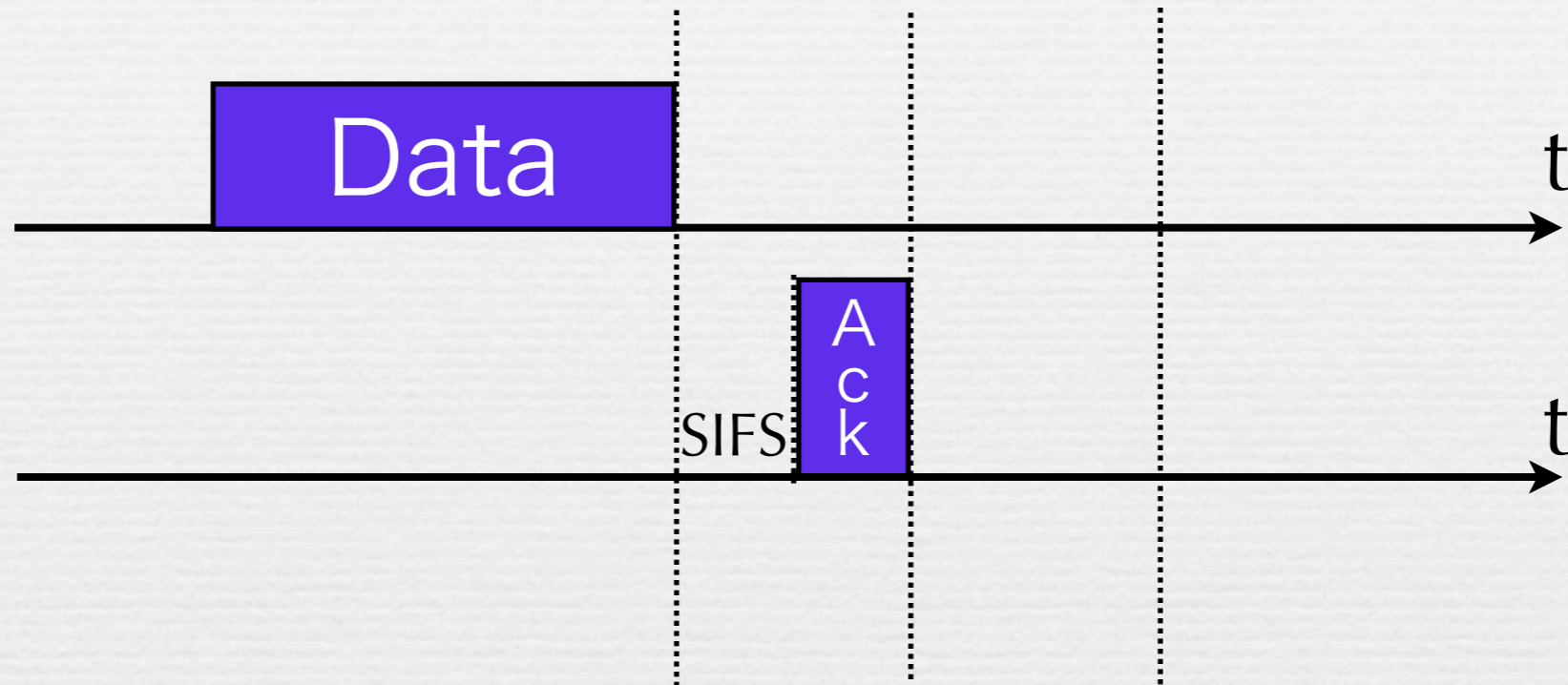
information only on the last frame in the retransmission process with a timestamp at the precision of 1024 usec.

Received Ack frame is timestamped by the receiving NIC at the precision of 1 usec.

Problem Summary

- A timestamp of a TX frame is at the precision of only 1024 usec.
- Packets of different packet traces are timestamped by the clocks of different NICs.
 - the clocks have skew and offset.

TX Timing Inference

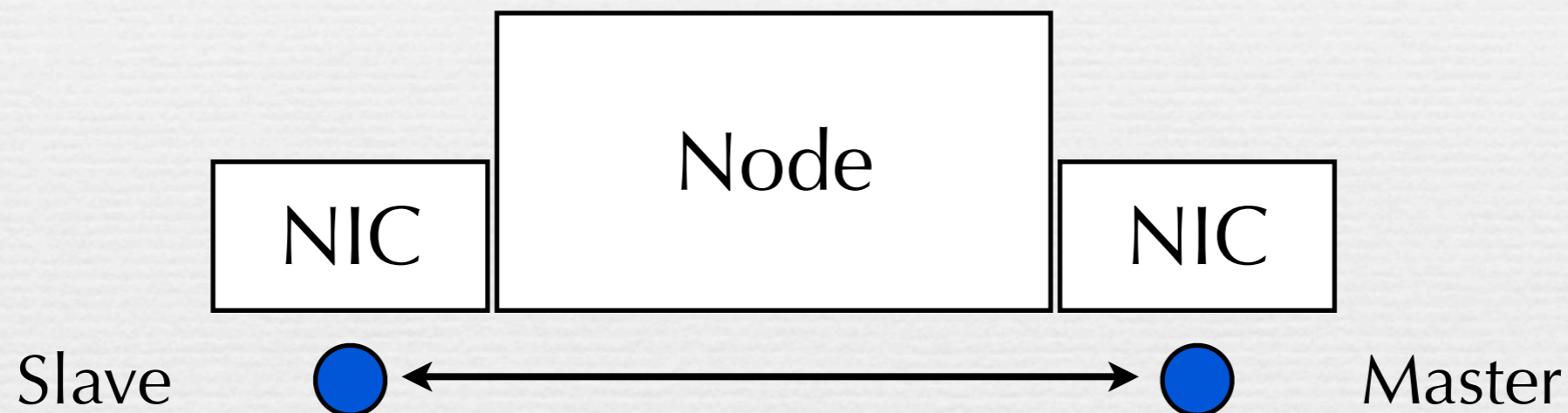


↑ infer TX timing from RX timing of the corresponding Acknowledgement frame

We confirmed the inferred timing is as precise as monitored one with a std of only 2.542 usec.

Time Synchronization(1)

- Time Synchronization between NICs

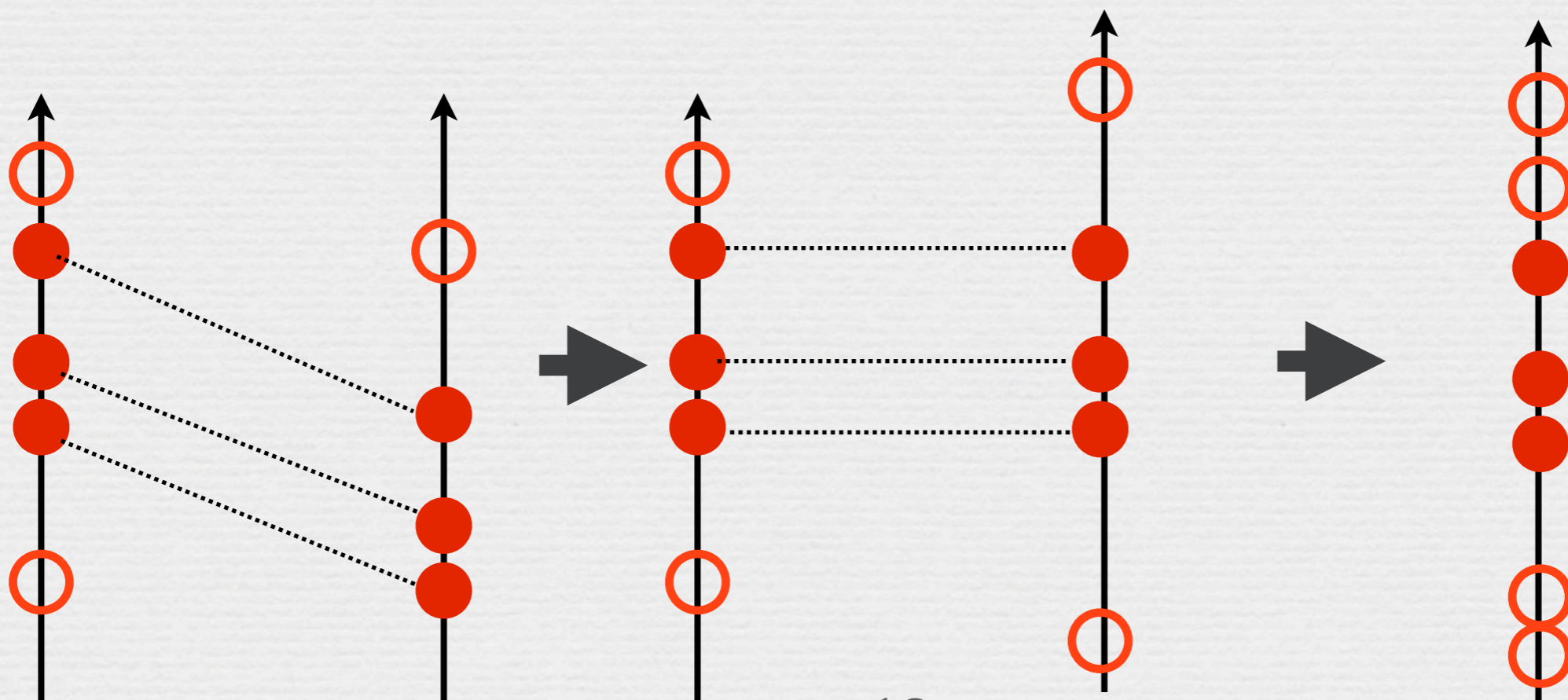


We measure the difference between the master and slave clocks regularly.

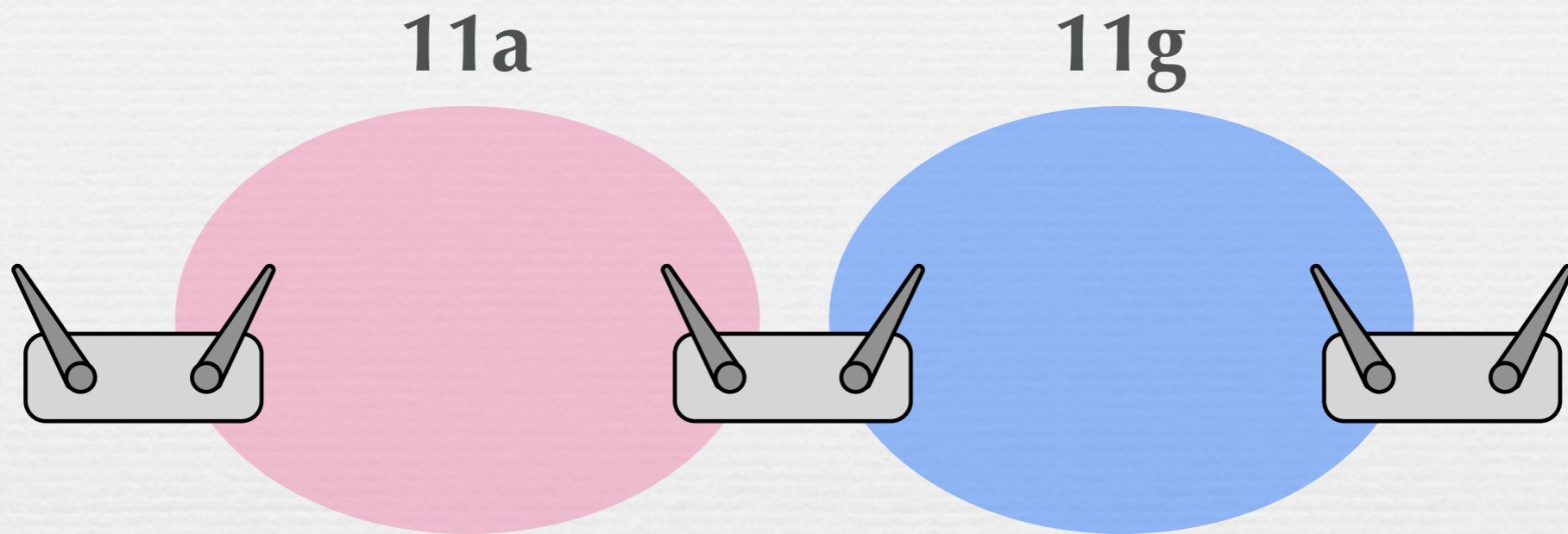
When we read the slave clock, we correct the value with this difference.

Time Synchronization(2)

- Time Synchronization between Nodes
 - decides offset and skew of 2 clocks by comparing two packet traces.



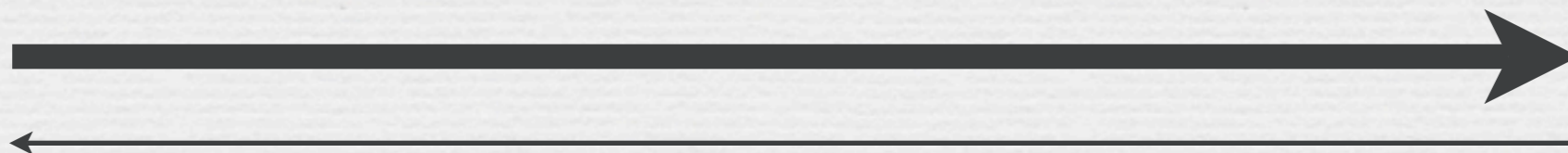
Preliminary Experiment



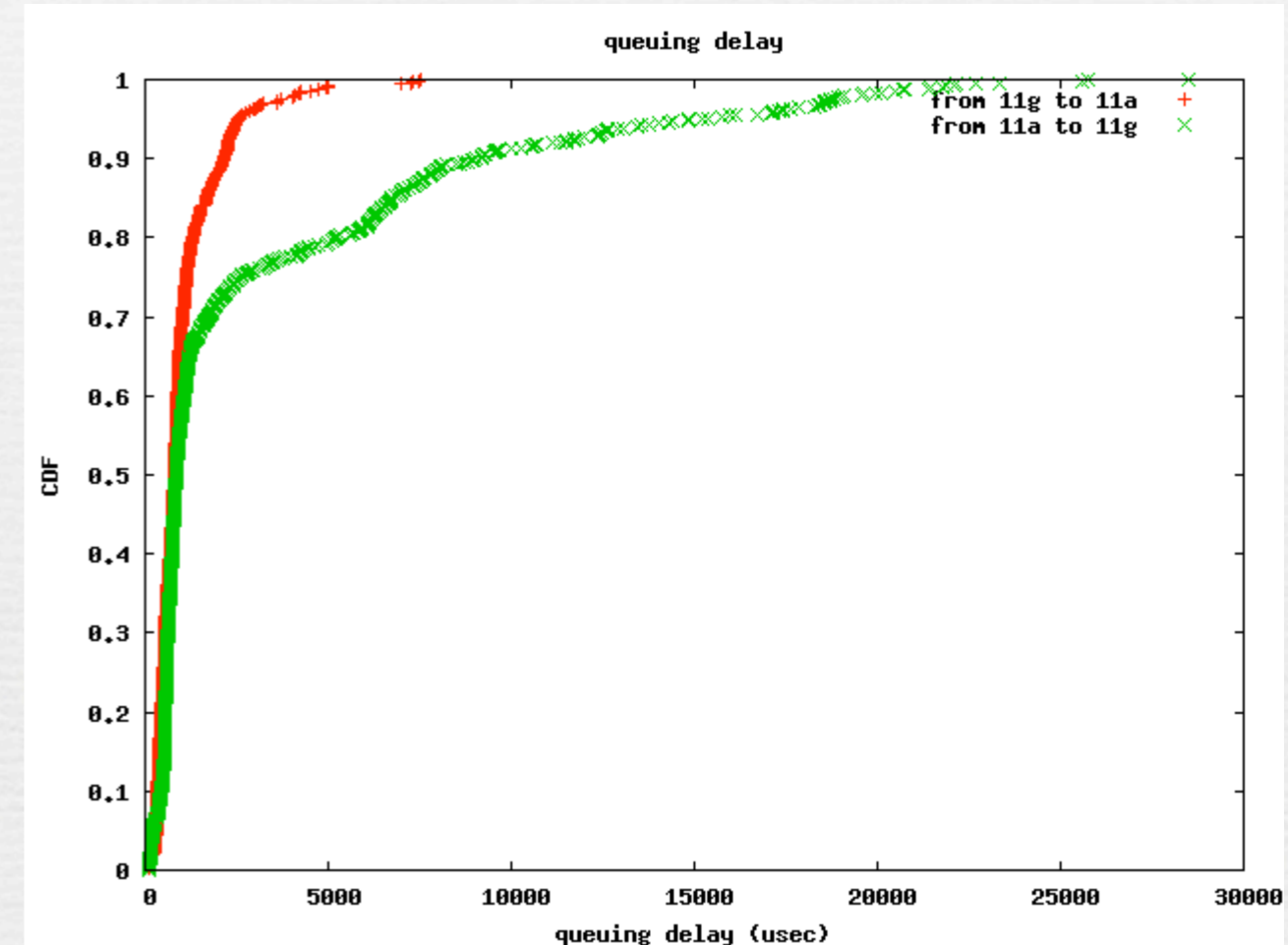
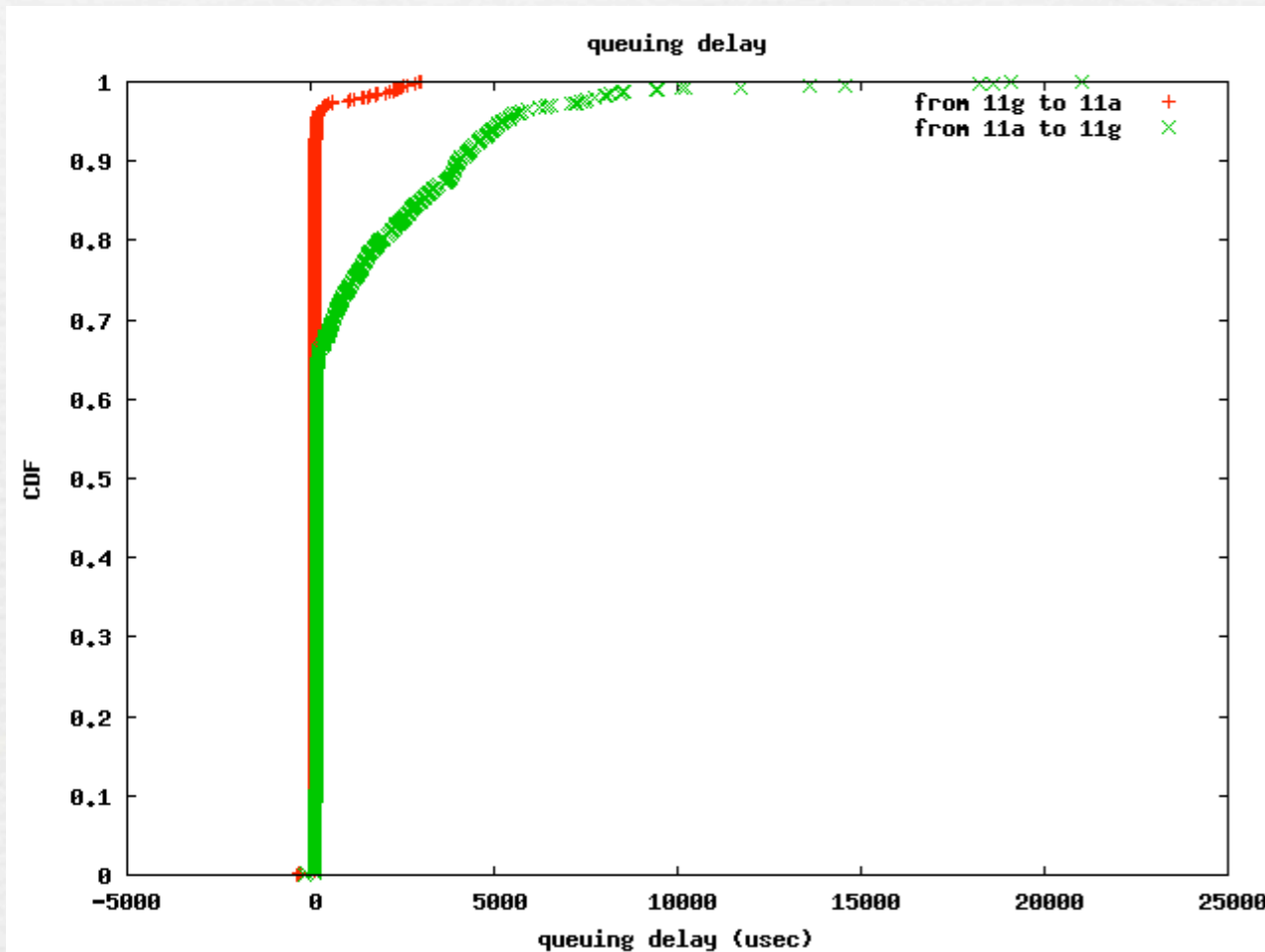
1. ICMP



2. TCP



Preliminary Results



ICMP queuing delay

TCP queuing delay

Future Works

- Apply the measurement technique to larger WMNs.
- Evaluating our previous works using this technique.
- Analyzing the merged packet trace in more detail.
 - To get conflict graph, interaction with TCP, and so on.

Conclusion

- We designed and implemented a architecture for WMNs to achieve seamless connectivity.
- We are developing a measurement technique for WMNs.