IoT protocols and Simulation Framework

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What is this about?

- Experience-sharing
  - Untrustworthy results
    - Protocols not realistic
    - IEEE papers give unrealistic data
  - Experiments done in limited scope
    - Difficult for fellow-researchers to try different settings
  - Comparative analysis is difficult
- My context
  - Multihop mesh routing protocols
  - Bigger networks (1K nodes, 16 hops), AMI scenario

What we want?

- Requirements
  - Benchmarking performance
  - Reproducible data
  - Data under realistic network conditions
  - Data with real-world IoT network stacks
  - Interop tests
  - Shareable scenario config

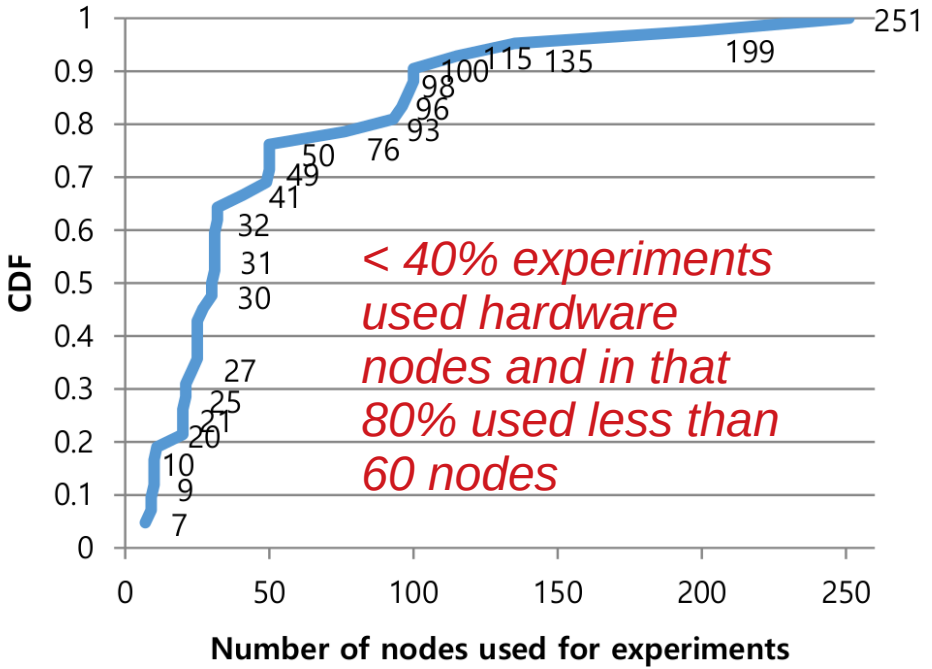
Realistic models are necessary

- Especially for wireless constrained networks
  - Asymmetric links
  - Impact of channel access
  - Inteference and collision patterns
- Performance data is important to be measured with realistic wireless modelling
  - Best is to use hardware, but it may not be possible!

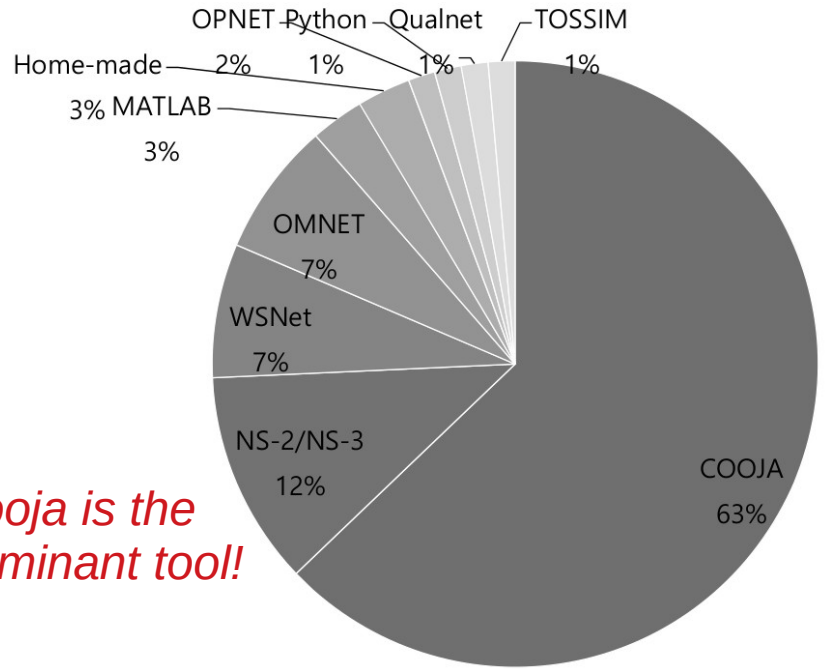
So, Yet another framework!

- Cooja
  - Very easy to use, good visualization, integrates contiki
  - Supports Hardware Emulation!
  - But not realistic: path loss and propagation models
  - Cannot scale: to hundreds of nodes
- NS3/Omnet++
  - Realistic models
  - But difficult to integrate with real-world stacks
  - What about NS3-TapBridge?
- Hardware Testbeds
  - Indriya, FIT/IOT-Lab
  - Practical data but limited scale
  - Difficult to debug, limited runtimes

Realistic Simulation Frameworks are difficult to use



< 40% experiments used hardware nodes and in that 80% used less than 60 nodes

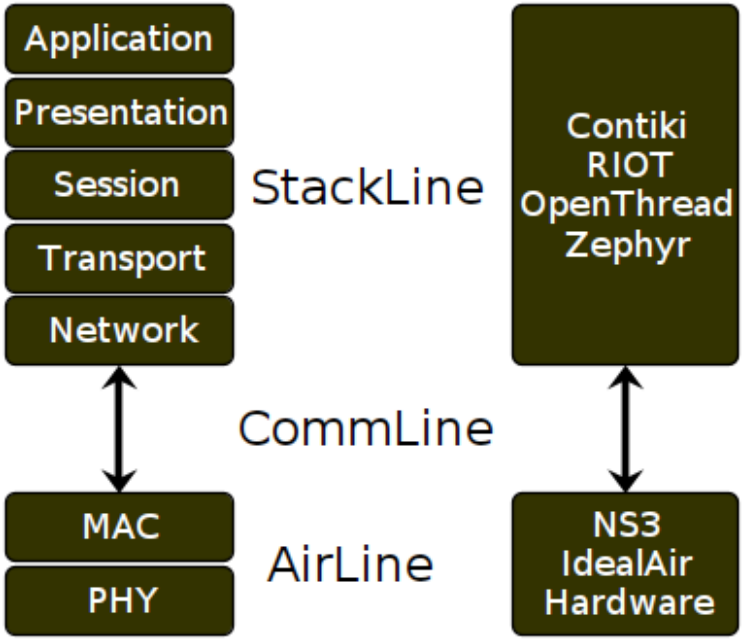


Cooja is the dominant tool!

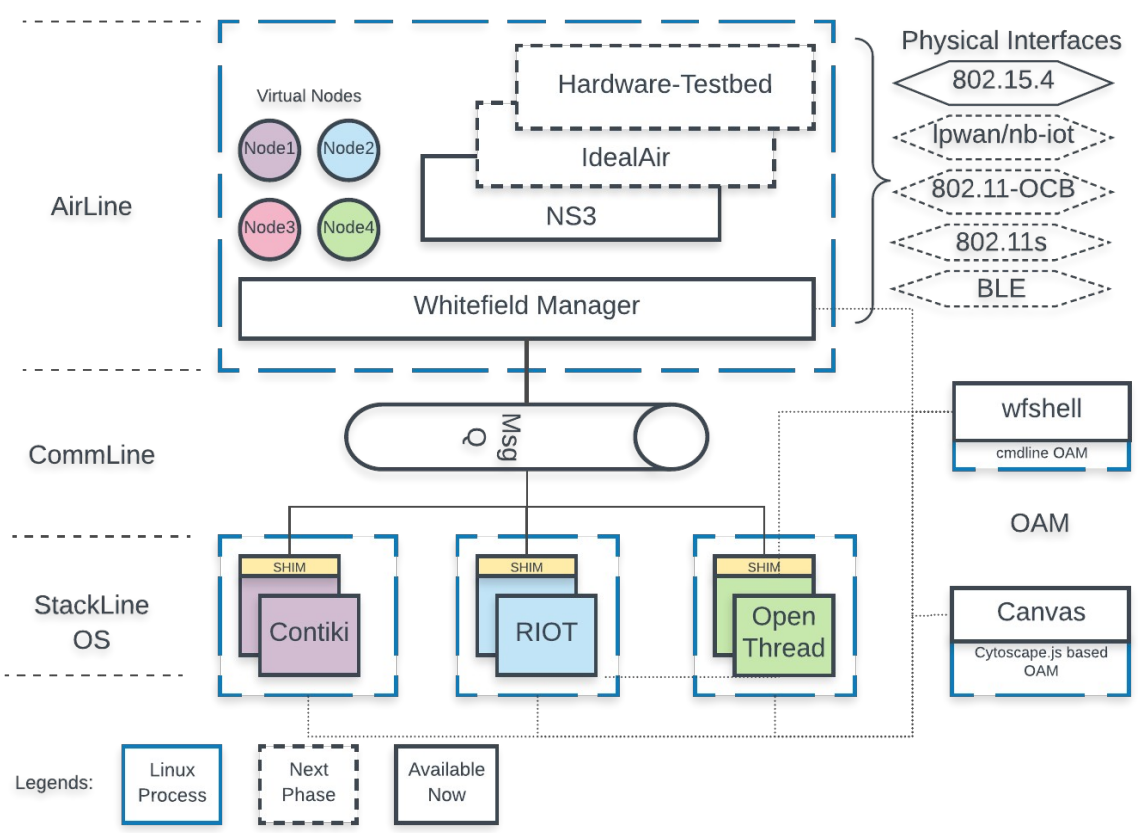
Ref: Challenging the IPv6 Routing Protocol for Low-Power and Lossy Networks (RPL): A Survey, Hyung-Sin Kim et.al.

Introducing Whitefield

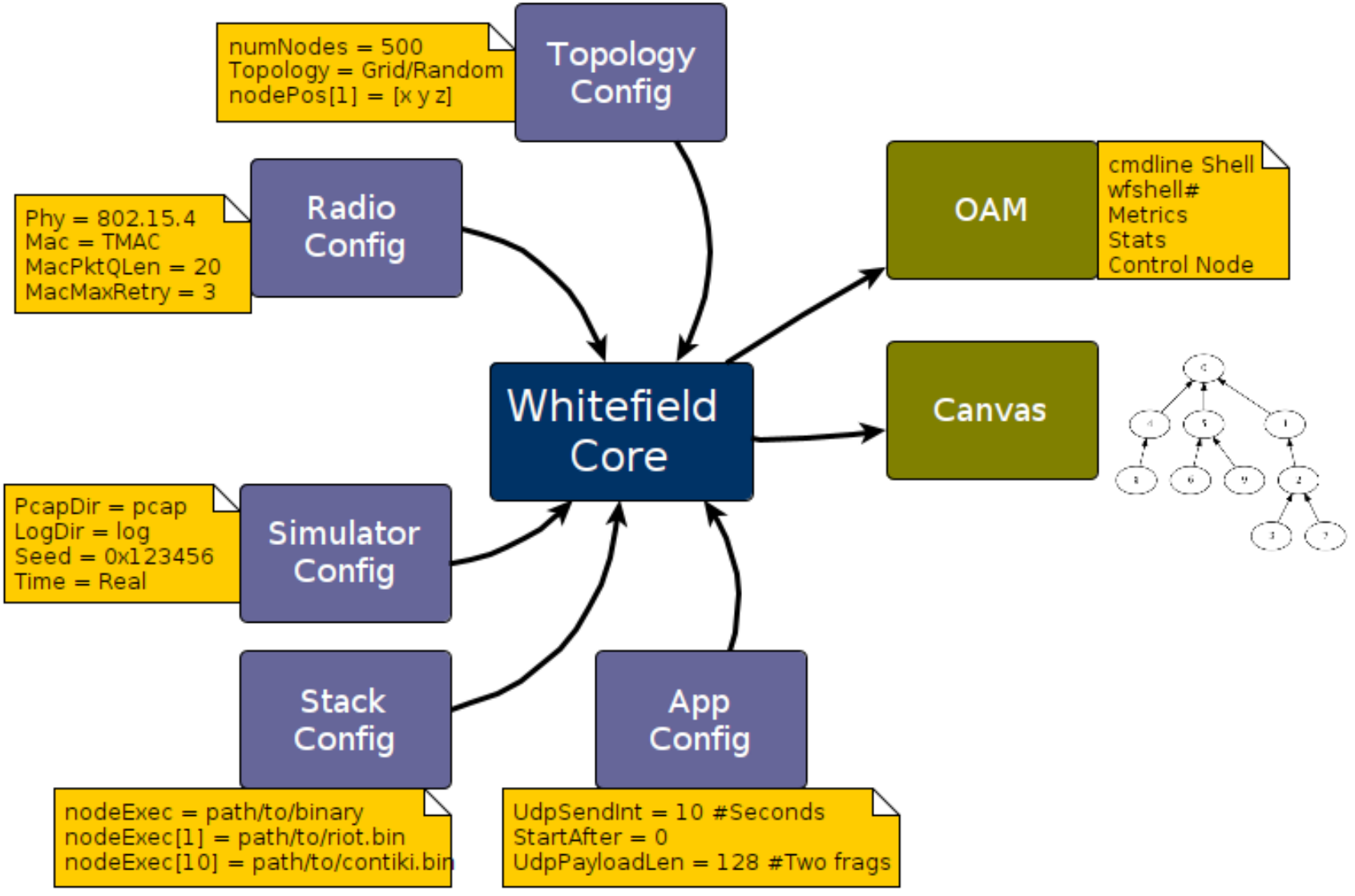
- Started during IETF96
- Design Goals
  - Integrate proven wireless models with real-world stacks
  - Scalable to thousands of nodes
  - Can migrate to hardware using the same setup
  - Cloneable setup
- Stacklines supported
  - Contiki, RIOT
  - OpenThread (support in progress)
- AirLine support
  - NS3
  - IdealAir (in progress)



High Level Design



- Contiki/RIOT/OpenThread have been added with Whitefield platform support (in whitefield org repo)
- Every StackLine node is a Linux process
- Mapping of StackLine node to virtual AirLine node
- Whitefield orchestrates the AirLine and StackLine processes
- AirLine, StackLine, CommLine decoupled
- CommLine currently uses abstract unix domain sockets
- Every node is identified by a unique ID
- Max 60K nodes possible
- Common OAM/Visualization


numNodes = 500
Topology = Grid/Random
nodePos[1] = [x y z]
Topology Config
Phy = 802.15.4
Mac = TMAC
MacPktQLen = 20
MacMaxRetry = 3
Radio Config
OAM
cmdline Shell
wfshell#
Metrics
Stats
Control Node
Whitefield Core
Canvas
PcapDir = pcap
LogDir = log
Seed = 0x123456
Time = Real
Simulator Config
Stack Config
App Config
nodeExec = path/to/binary
nodeExec[1] = path/to/riot.bin
nodeExec[10] = path/to/contiki.bin
UdpSendInt = 10 #Seconds
StartAfter = 0
UdpPayloadLen = 128 #Two frags

Case-Study-1

- draft-ietf-roll-rpl-observations
  - For the first time we could test interop between RIOT and Contiki at scale
    - RPL DAO aggregation not handled in Contiki
    - Reported RPL DAO fragmentation issue on RIOT ML (ref)
    - Essentially could not interop at scale
  - Network convergence time for 300 Contiki nodes
    - With Cooja was <20s
    - With Whitefield it was 1-2mins with very high variation depending on app-traffic
    - With hardware we found similar convergence time
      - We actually had 300 node hw setup!
    - Control Overhead was very different

Case-Study-2

- draft-ietf-roll-efficient-npdao
  - Impact of optimized invalidation on overall network performance
  - Numbers drastically vary from Cooja
    - Numbers with Cooja are actually very good, but misleading

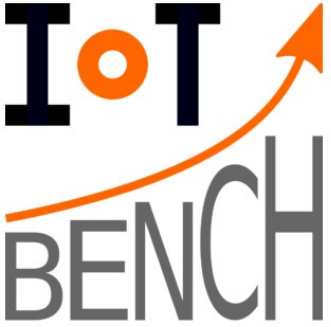
More Case-Studies

- draft-ietf-lwig-nbr-mgmt-policy
  - Impact of neighbor cache policy on the stability of the network
- draft-ietf-6lo-minimal-fragment
  - Impact of 802.15.4 single channel operation on fragment forwarding

Detailed setup config, observations and raw data is present on the Whitefield-framework github

Other work in the context

- IoTBench
  - *“A community effort to better evaluate and compare low-power wireless network”*
  - Provides excellent conceptual framework
  - Enlists tools and testbeds in the context
- Whitefield will use the recommendations
  - Organizing the suites, metrics, configuration
  - Use of profiles for ease of management



https://github.com/whitefield-framework/whitefield

Future Extensions: https://trello.com/b/9bdugZxX/project-whitefield

Questions: rahul.ietf@gmail.com