



# Institute for the Wireless Internet of Things

at Northeastern University

## Introduction to Colosseum for First Time Users

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Platforms for Advanced  
Wireless Research



**N**COLOSSEUM  
at Northeastern University

# Colosseum First Time Users

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- Quick Review of the Colosseum Architecture
- Details of Two of the Main Components, SRN and MCHEM
- Live Demonstration of How to Access the Colosseum Resources and Running an Experiment
- Working on Colosseum Containers in a Local Computer
- Hands-on Exercises for Wireless Network Emulation

**Note 1:** WiFi & LTE containers used in this course and other LXC containers used in this class are available to users.

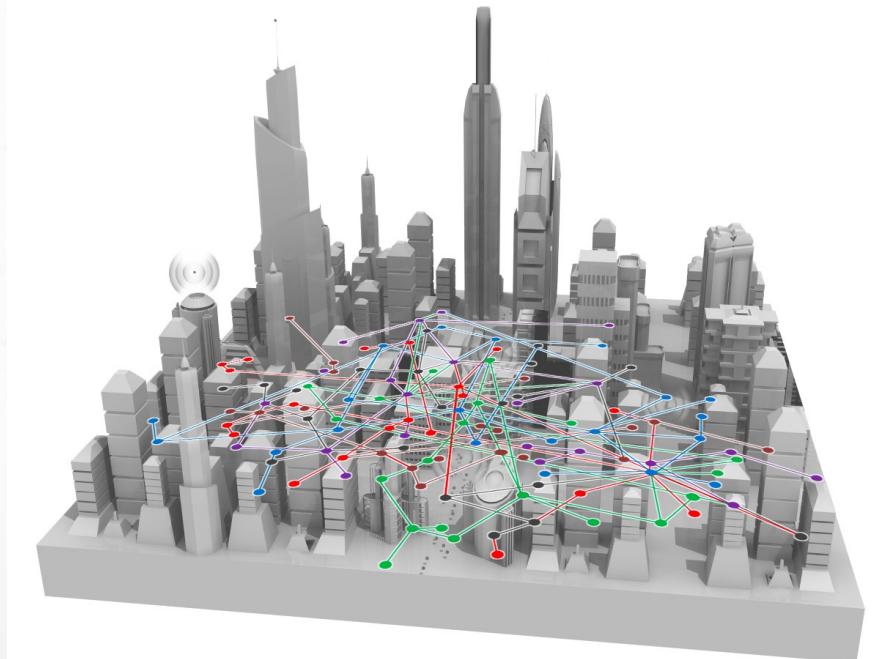
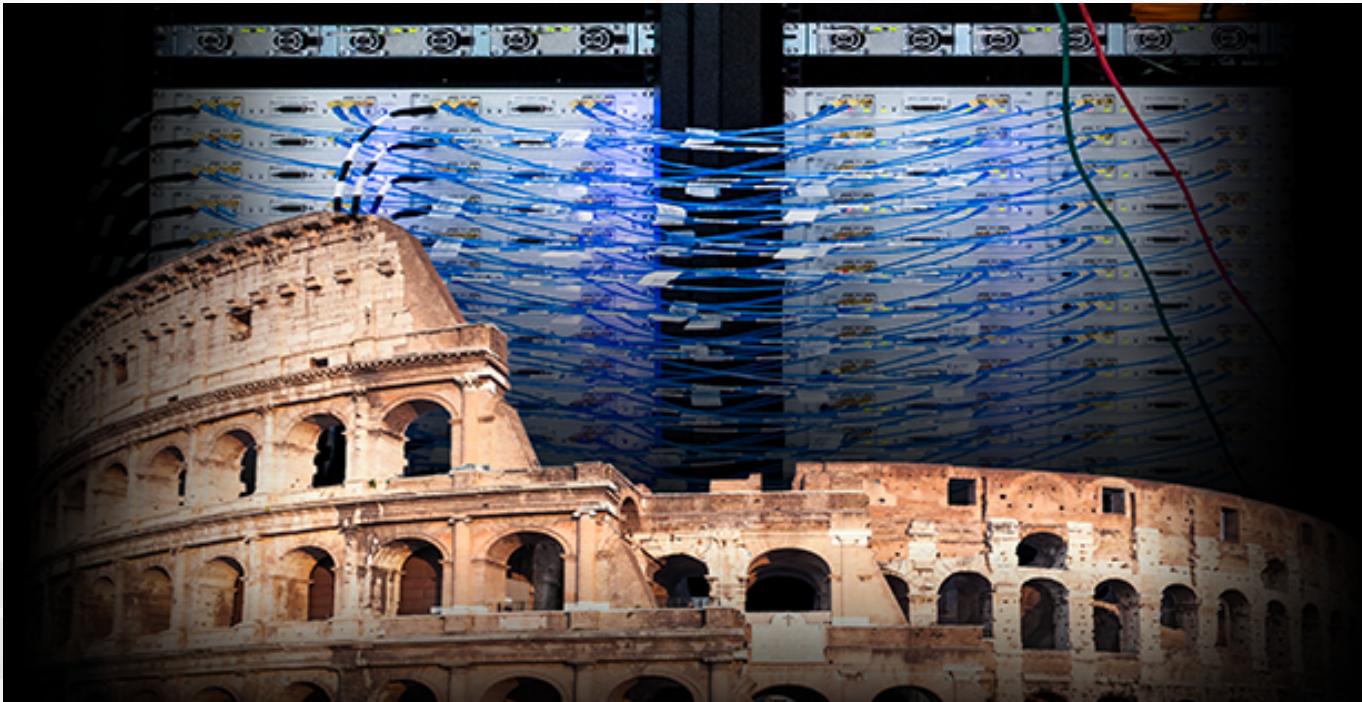
**Note 2:** Detailed tutorials with PowerPoint slides and recorded videos are also available for your future reference.

**Note 3:** Complete steps for today's demo is available at: [Webinar Demo](#)

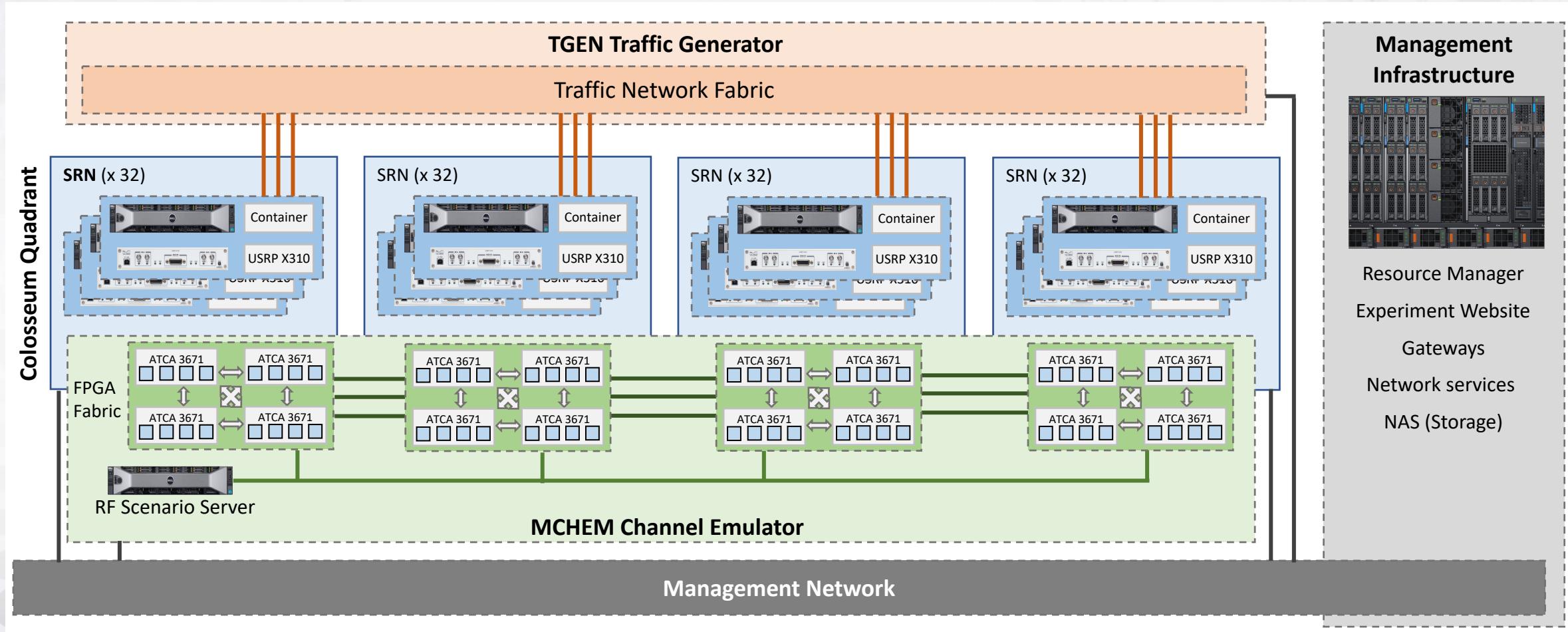
**Note 4:** Feel free to reach out if you are not currently a user but would like to join.

# Colosseum: The World's Largest Wireless Emulator

- 256 software defined radios (fully programmable)
- Fabric of field programmable gate arrays - > 65k channels emulated in real time
- 128 servers w/ hardware in the loop, remotely available for user experiments
- Diversified scenarios for better generalization of ML / AI models
- Large-scale experimentation of wireless RF systems with spectrum in the loop

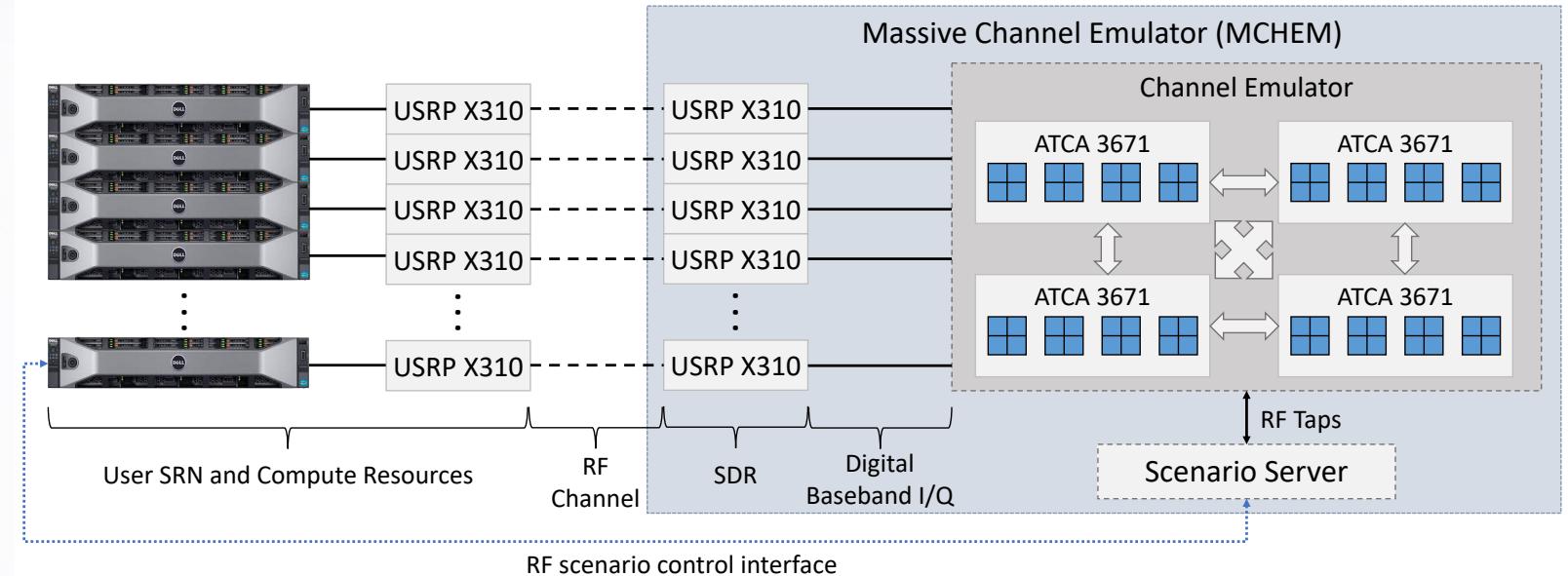


# Colosseum Architecture

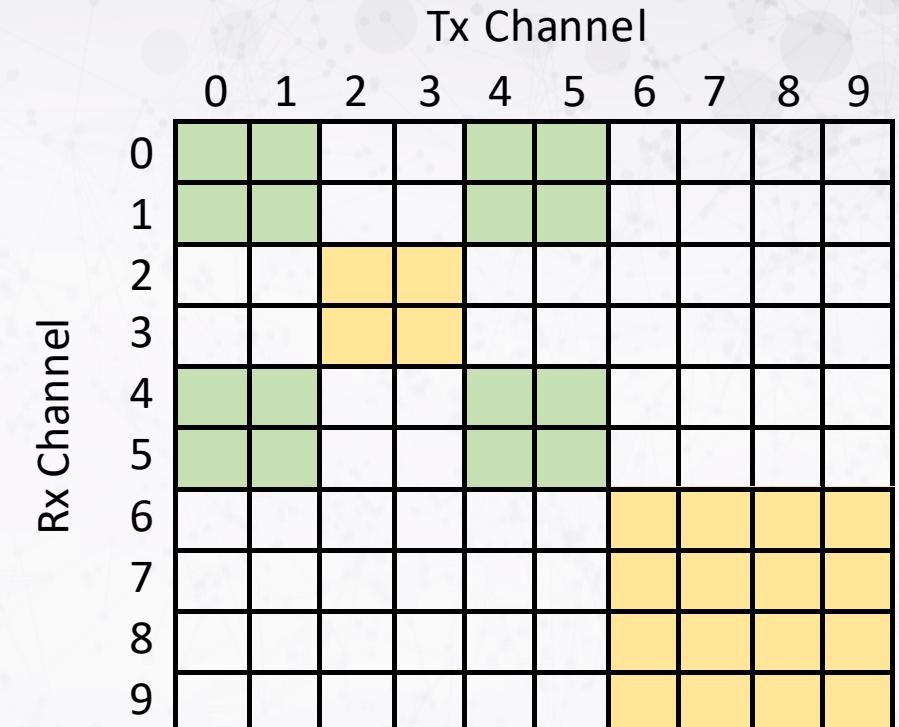
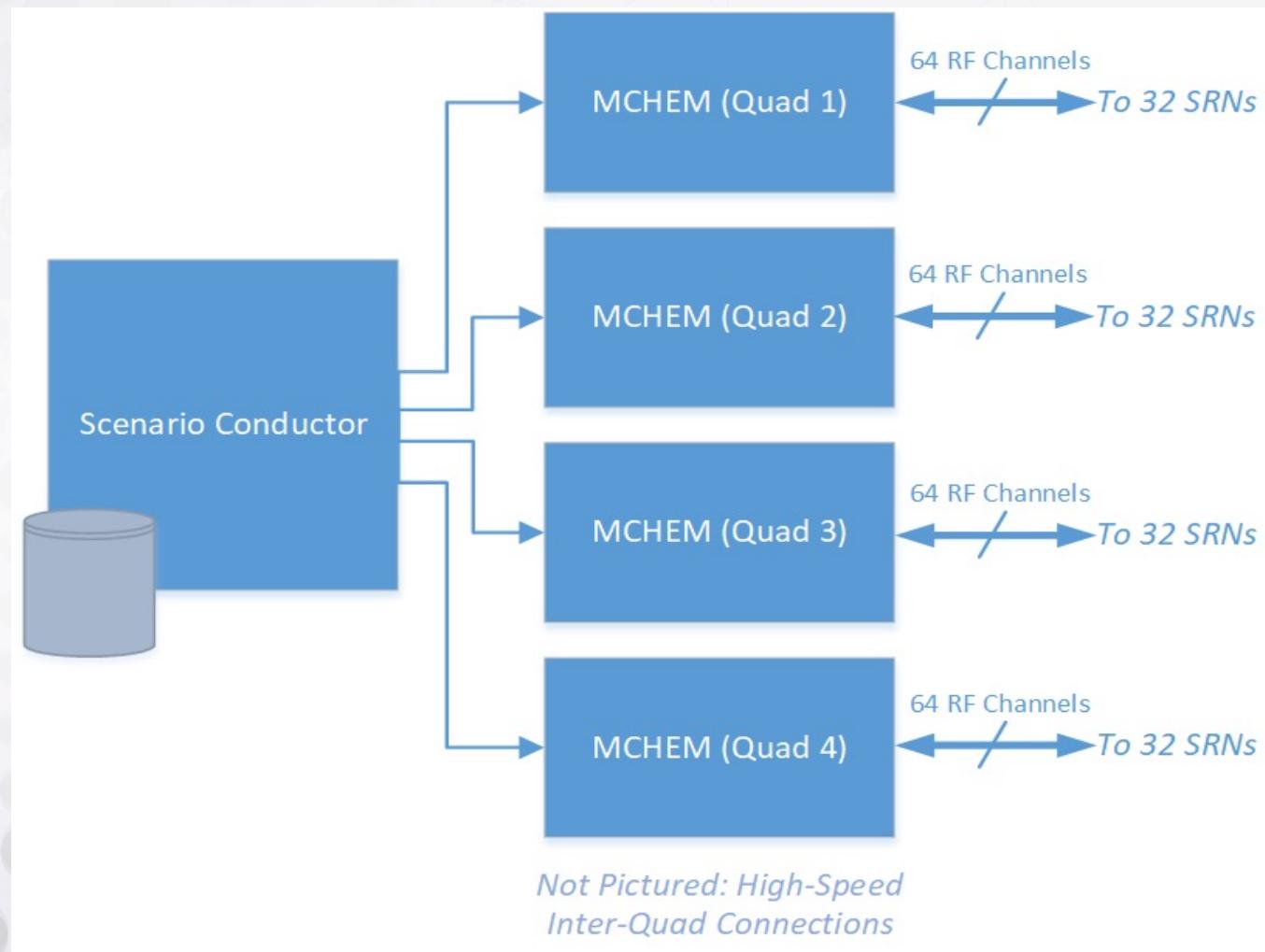


# Massive Channel Emulator (MCHEM)

- Scenario/reservation request is made through website
- Scenario conductor (manager) configures radios for scenario
- Scenario conductor (streamer) begins to stream coefficients into MCHEM
- SRN radios (USRP)s transmit into MCHEM radios (USRP)s
- Baseband IQ for each MCHEM radio is processed/filtered according to the channel model (defined by streaming coefficients)
- Filtered outputs are aggregated/summed according to the channel mapping (which SRN radios should receive the composite signals)
- MCHEM radios transmit composite signals to the appropriate SRN radios



# Scenario Conductor



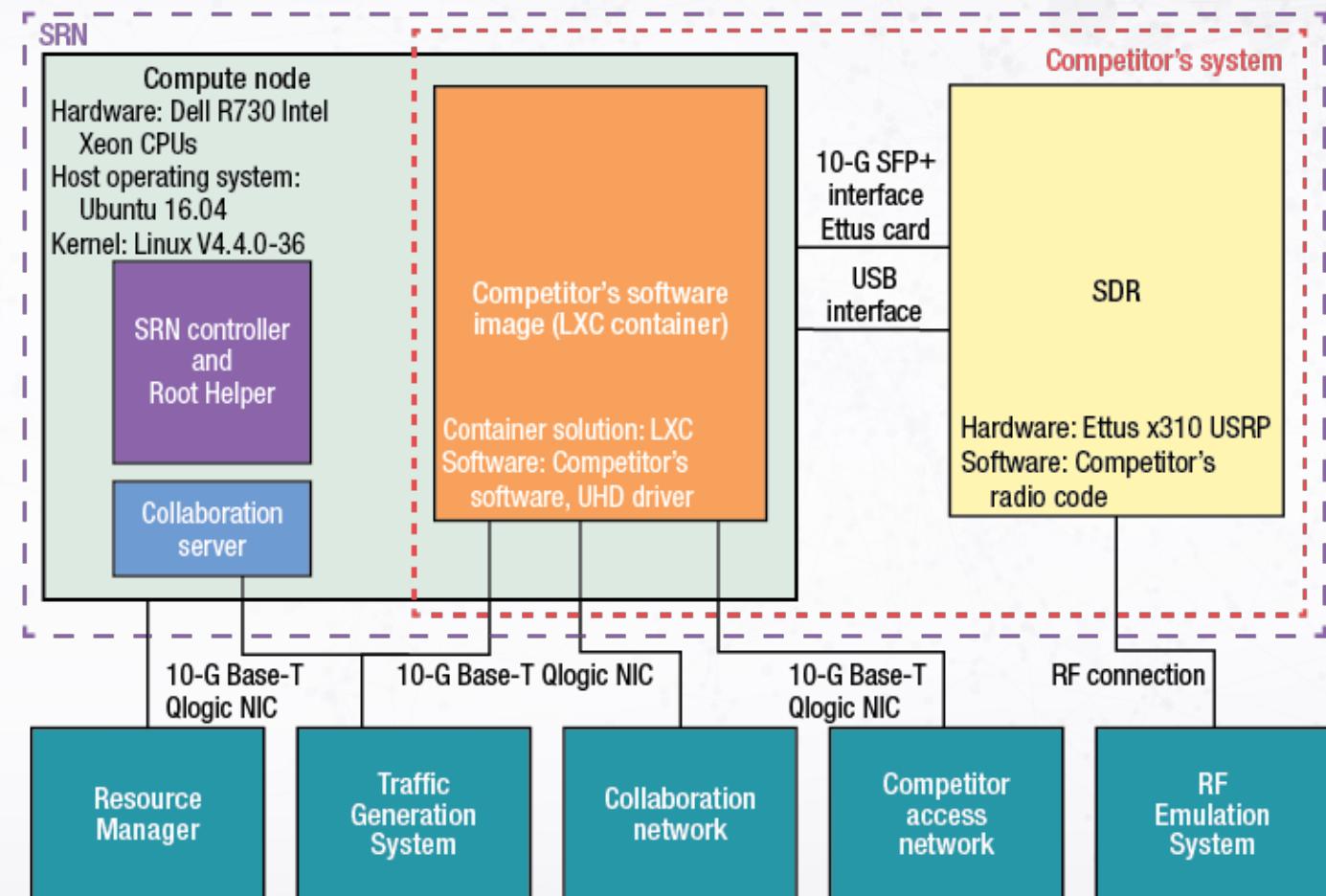
## Legend

- Reservation A - Channels 0,1,4,5
  - Reservation B - Channels 2,3,6,7,8,9
  - Connectivity Disabled
- N** Institute for the Wireless Internet of Things  
at Northeastern

# Standard Radio Node (SRN)

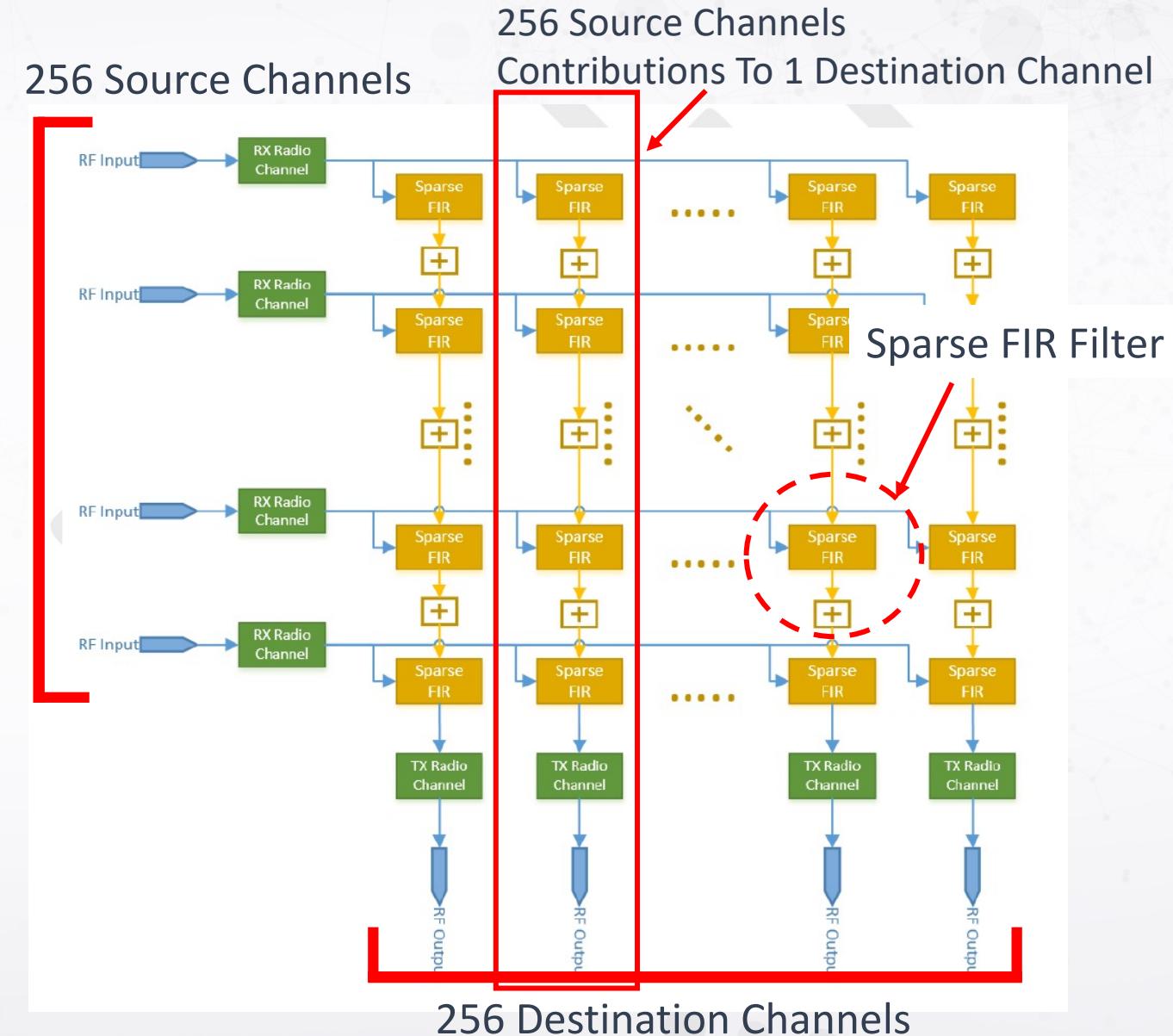
Each SRN has 3 key hardware components:

- Dell R730 Server
  - 128GB Memory
  - 1TB Hard Drive
- Ettus X310 USRP Software Defined Radio
  - 100MHz Bandwidth
  - Onboard FPGA: XILINX Kintex 7 – 410T
- NVIDIA K40M GP-GPU



# Channel mapping

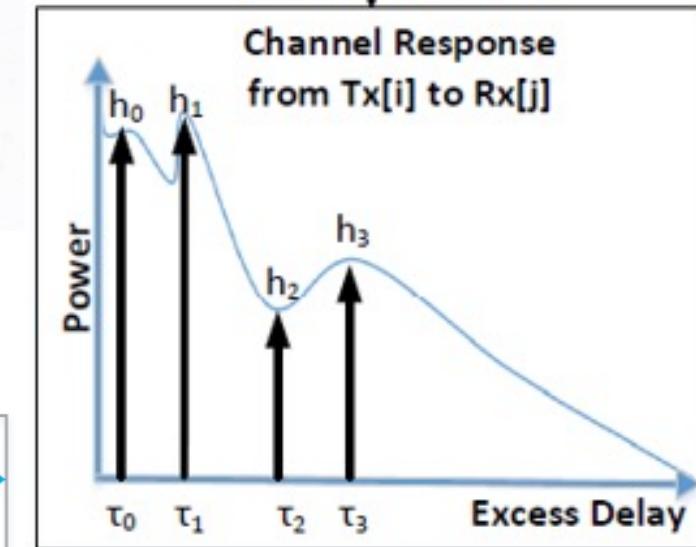
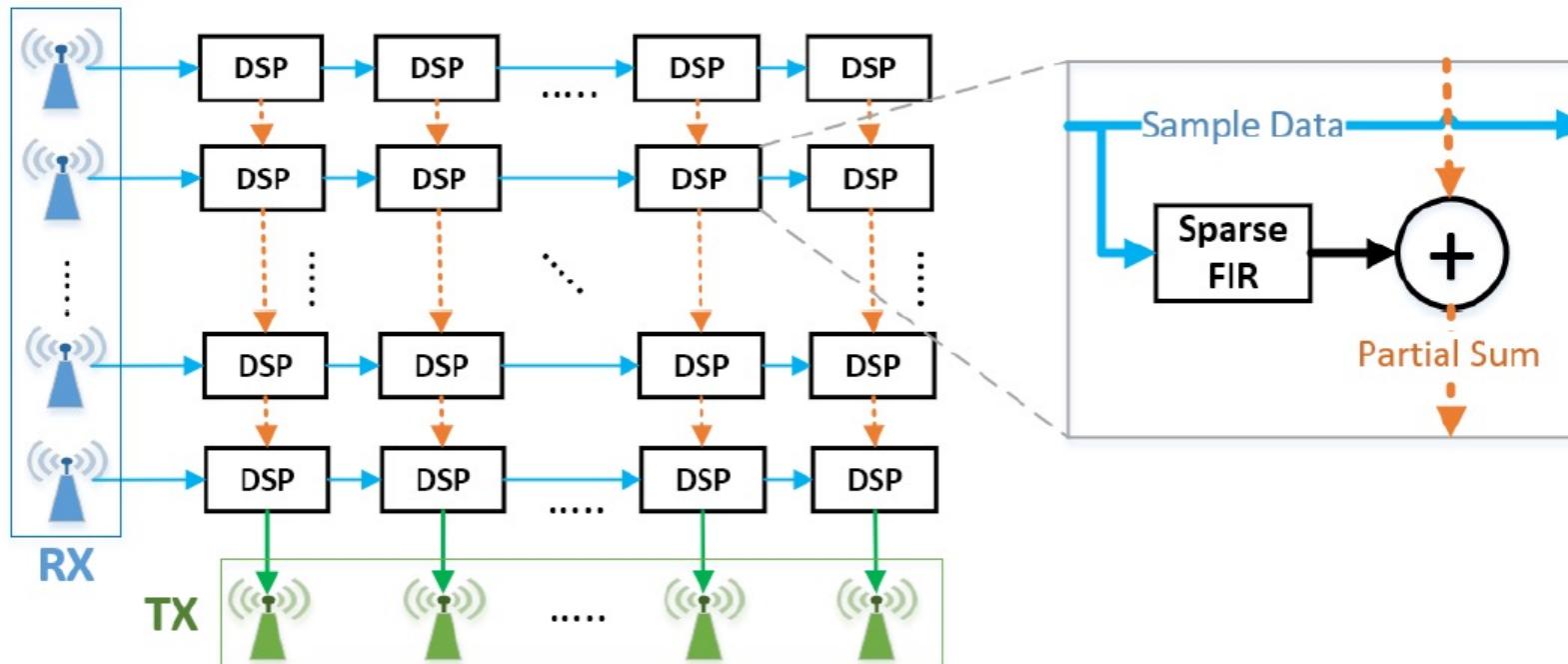
- MCHEM provides radio channel pair mapping across all 256 radio channels
- Destination channel can have up to 256 contributing source channels
- For each destination channel, the signals provided by source channels are filtered individually according to the channel model



# Channel mapping

- Mapping is implemented as a grid (“Computation Matrix”) of interconnections, where each interconnection is a FIR output.
- FIR is used to model source radio channel’s contribution towards destination radio channel’s spectrum.
- 512 taps with 10ns spacing, only 4 non-zero taps can be defined.

## Computation Matrix

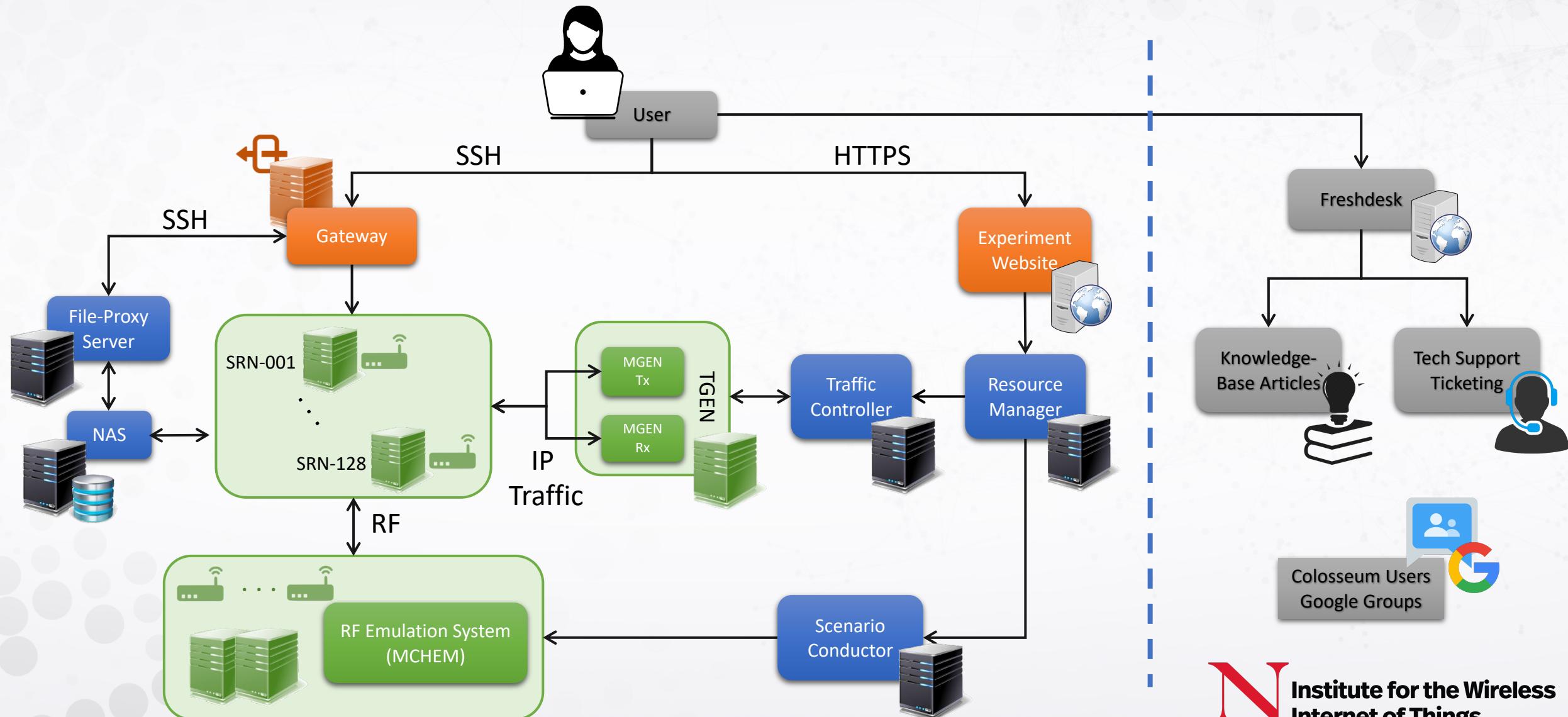


Power Delay Profile (PDP) for channel pair  $(i,j)$ , representative of channel model

# MCHEM Imposes Some Constraints

Chanel Emulator Constraint	Source	Scenario Definition Impact
128 USRP X310s each with 2 UBX-160-LP RF Daughter Cards	Channel Emulator Design	Maximum of 128 2x2 MIMO Nodes
100 MSps Sampling Rate	FPGA Processing Bandwidth	3 meter distance resolution
10 ns Tap Delay Resolution		
80 MHz Usable Channel Bandwidth	RF Daughter Card Bandwidth	
4 non-zero complex taps per RF channel from -1.0 to +1.0 [Q15 fixed-point for each I and Q value]	FPGA Constraint	
5.12 us max tap delay	FPGA Delay Line Length (512 element buffer)	Delay Spread limited to 5.12 us Propagation Delay + Excess Delay <= 5.12 us Maximum distance between TX/RX nodes is 1.5km
1kHz Channel Update Rate (1ms coherence time)	FPGA Constraint	Constrains Maximum Doppler Spread and limits node velocity to e.g., ~11.6mph at 5.8 GHz

# Quick Review of Colosseum Architecture



# Links to Colosseum Resources and Documentations

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- Colosseum Home Page
  - <http://colosseum.net>
  - <https://northeastern.edu/colosseum>
- Colosseum Experiment Portal
  - <https://experiments.colosseum.net>
- Freshdesk Users Support
  - Knowledge Base: <https://colosseumneu.freshdesk.com/support/solutions>
  - Helpdesk: <https://colosseumneu.freshdesk.com/support/tickets>
- Colosseum Users Google Group
  - <https://groups.google.com/g/colosseum-users>

