

# GENI LTE Testbed

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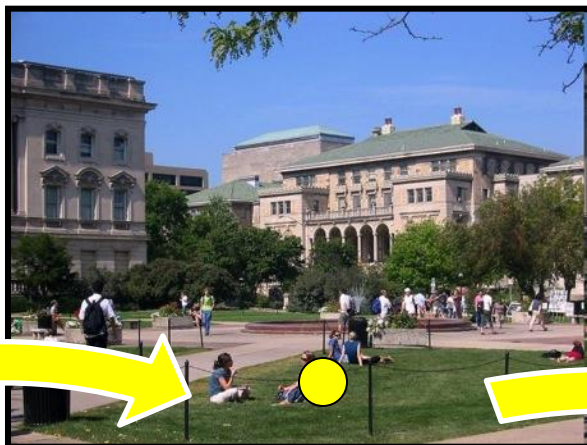
*Rutgers University*

*<http://groups.geni.net/geni/wiki/WirelessFGRE2016>*

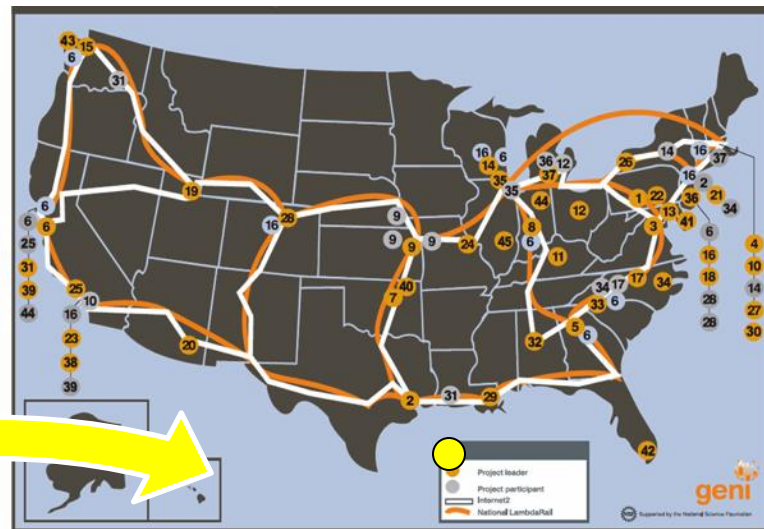
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GENI-enabled equipment



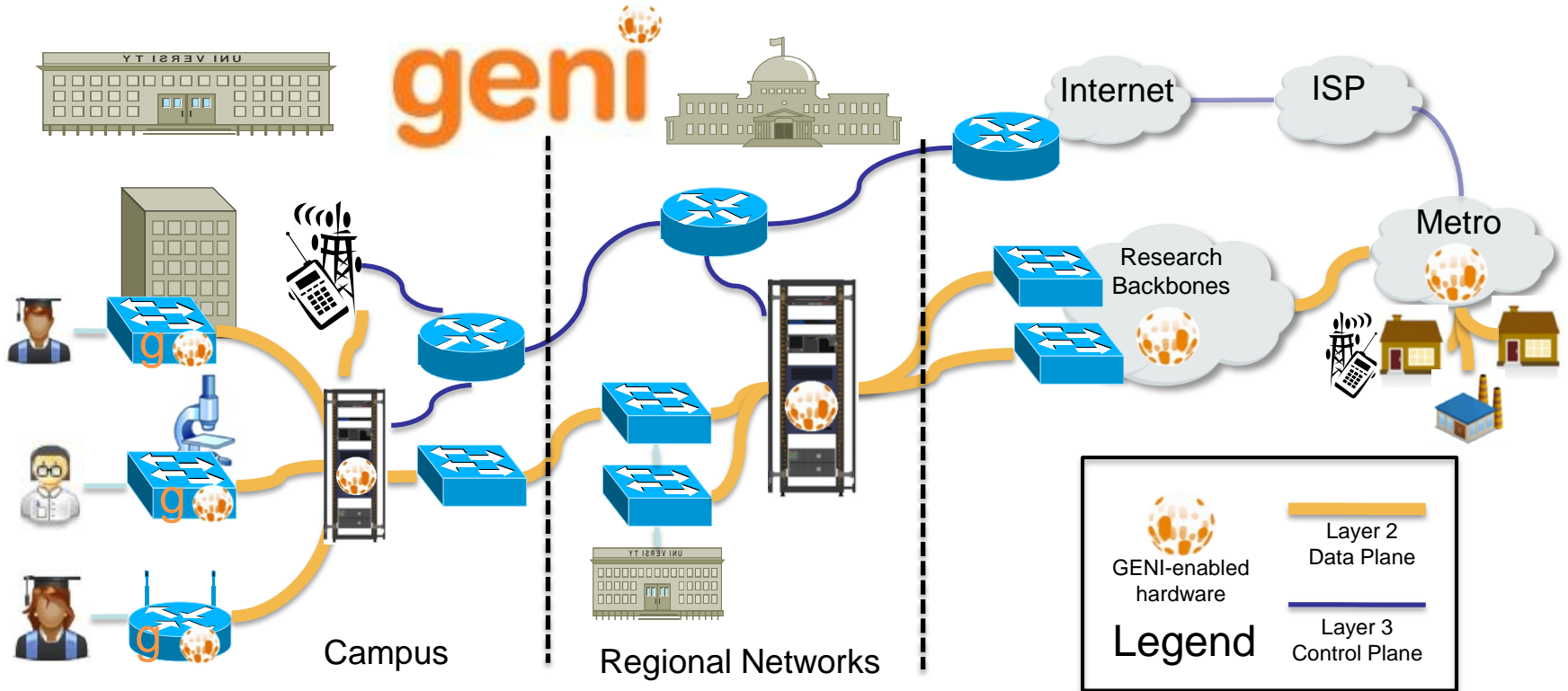
GENI-enabled campuses, students as early adopters



“At scale” GENI prototype

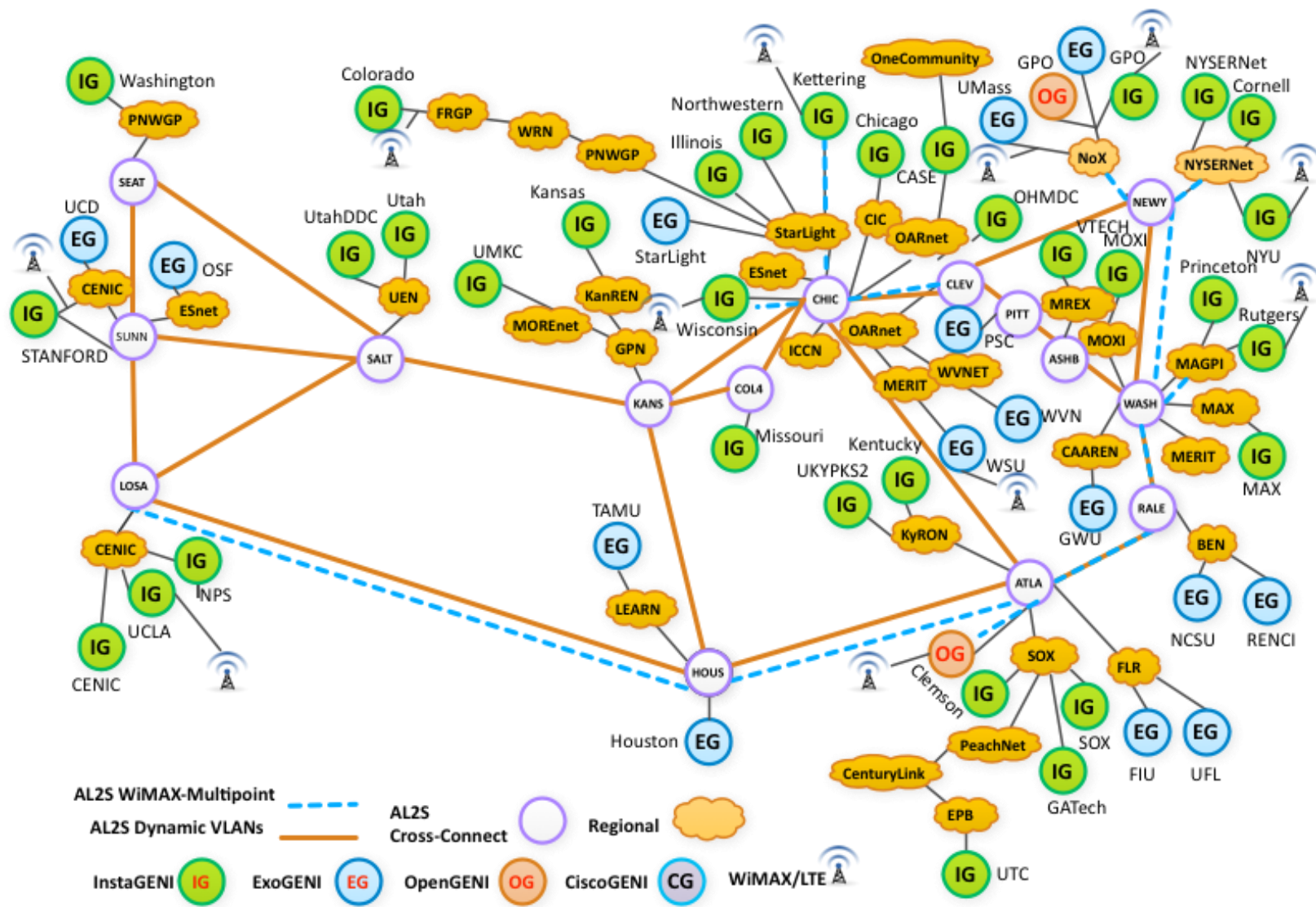
GENI-enable testbeds, commercial equipment, campuses, regional and backbone networks

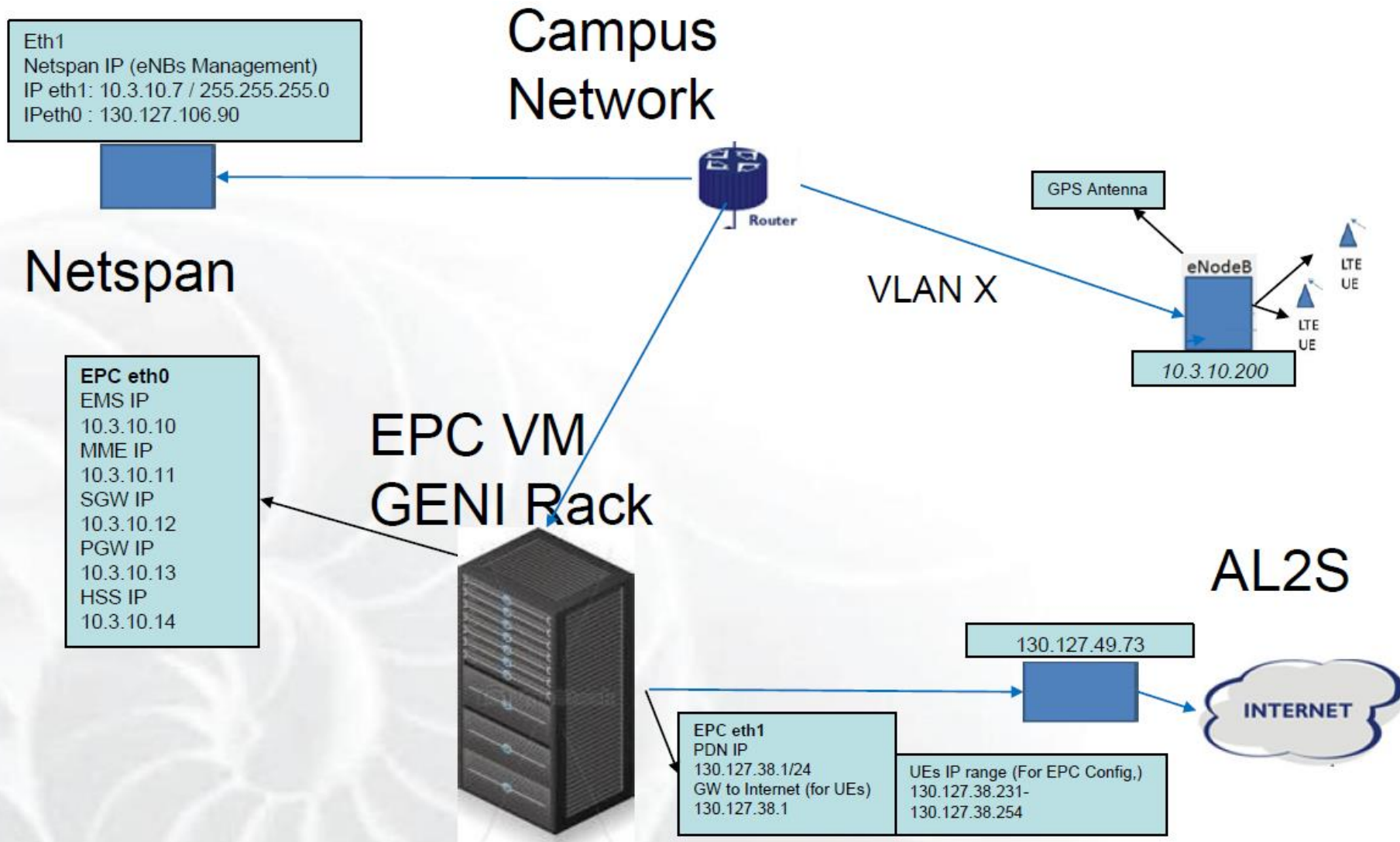
Campus photo by Vonbloompasha



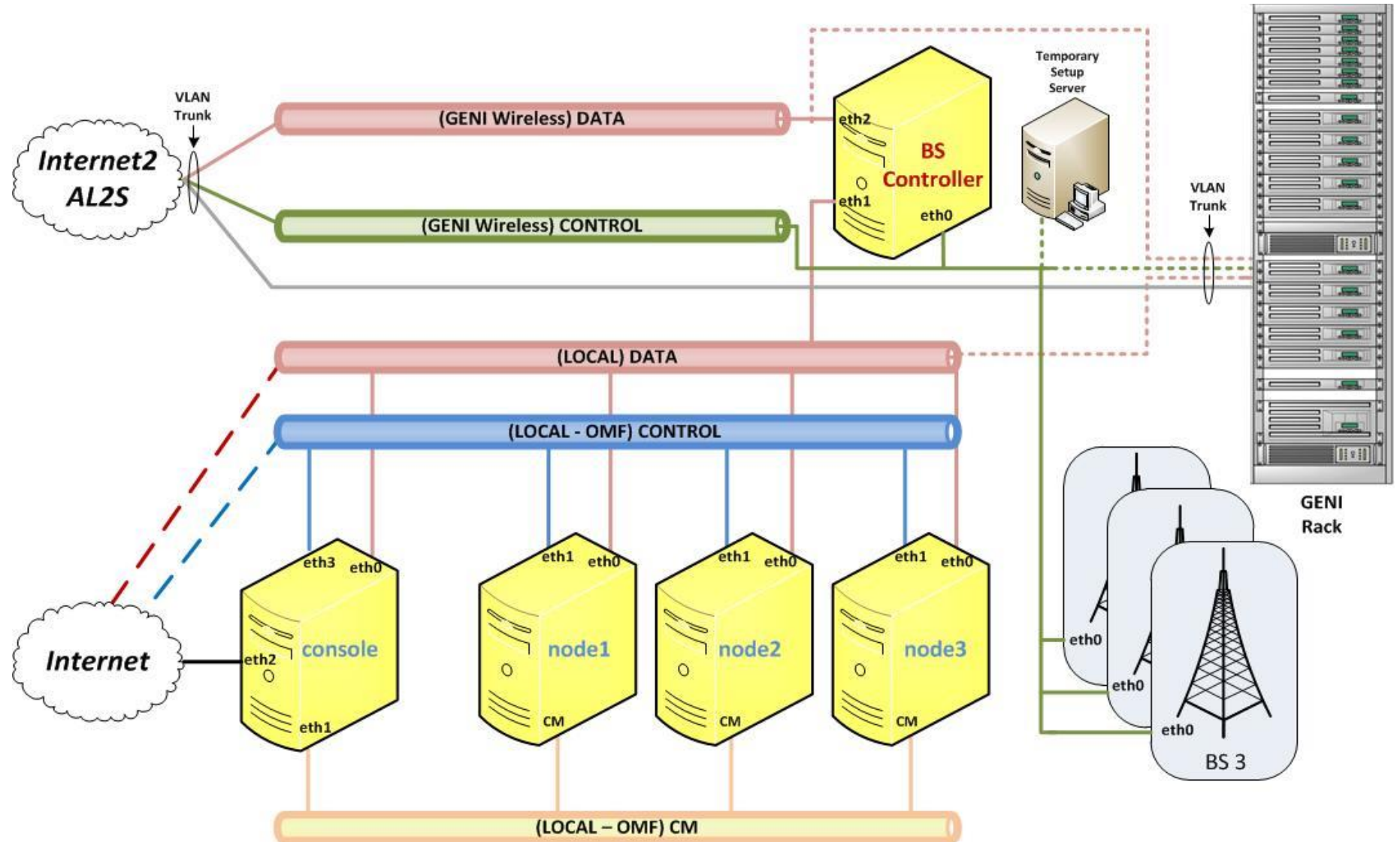
- Flexible network / cloud research infrastructure
- Distributed cloud (racks) for content caching, acceleration, etc.
- Also suitable for physics, genomics, other domain science

# Current GENI Deployment

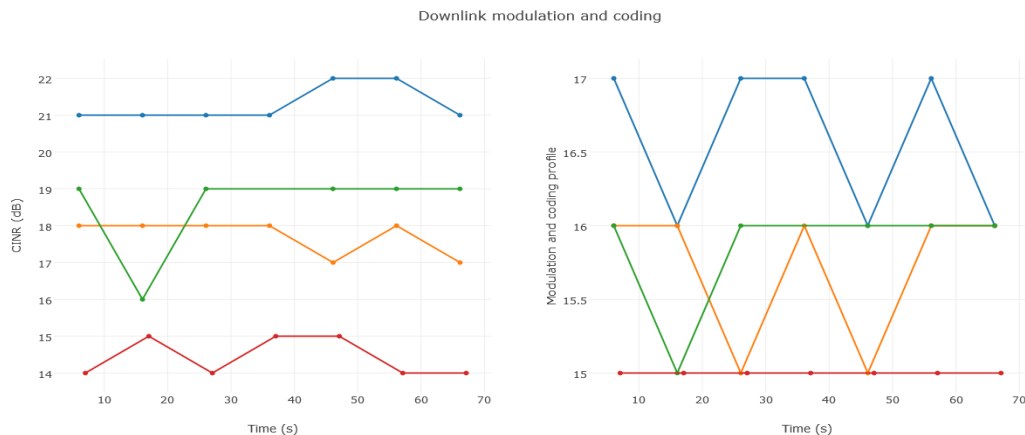
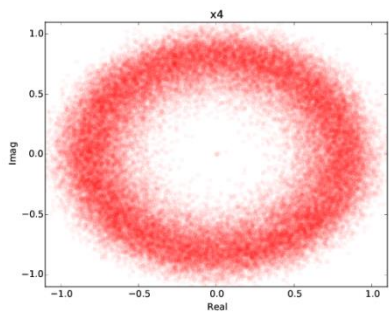
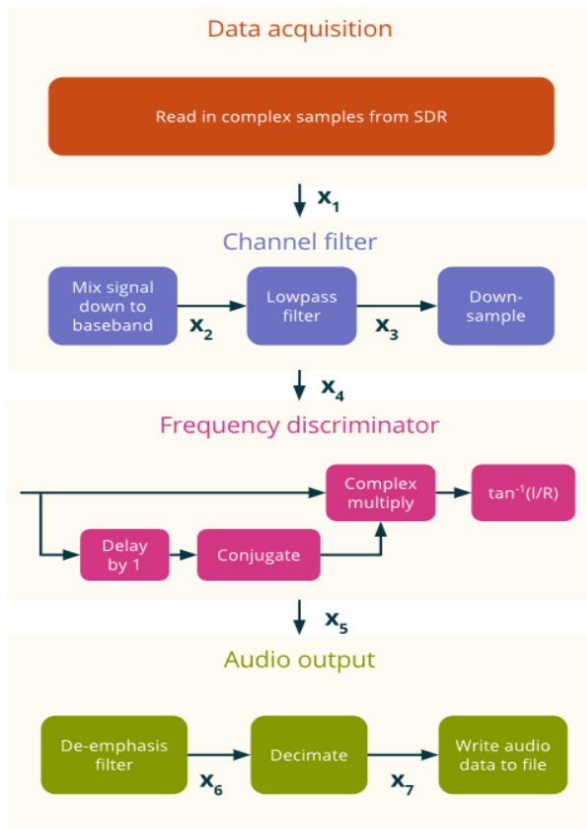




# LTE Campus deployment



- ✓ Help determine Location for LTE BS deployment.
- ✓ Negotiate Installation Quote from Facilities Engineering Dept.
- ✓ Provide Ethernet/Fiber network drops for BS.
- ✓ Provide Power outlets for BS.
- ✓ Configure VLAN(s) on campus network for backhaul network to Control Server.
- ✓ Configure Netspan Server ( if not already in place)
- ✓ Configure EPC VNF VM(s) on GENI Rack
- ✓ Configure VLAN on GENI Rack to connect BS to GENI L2 AL2S Network.
- ✓ Provide a public IP subnet from Control Server to allow Internet access from User Devices.

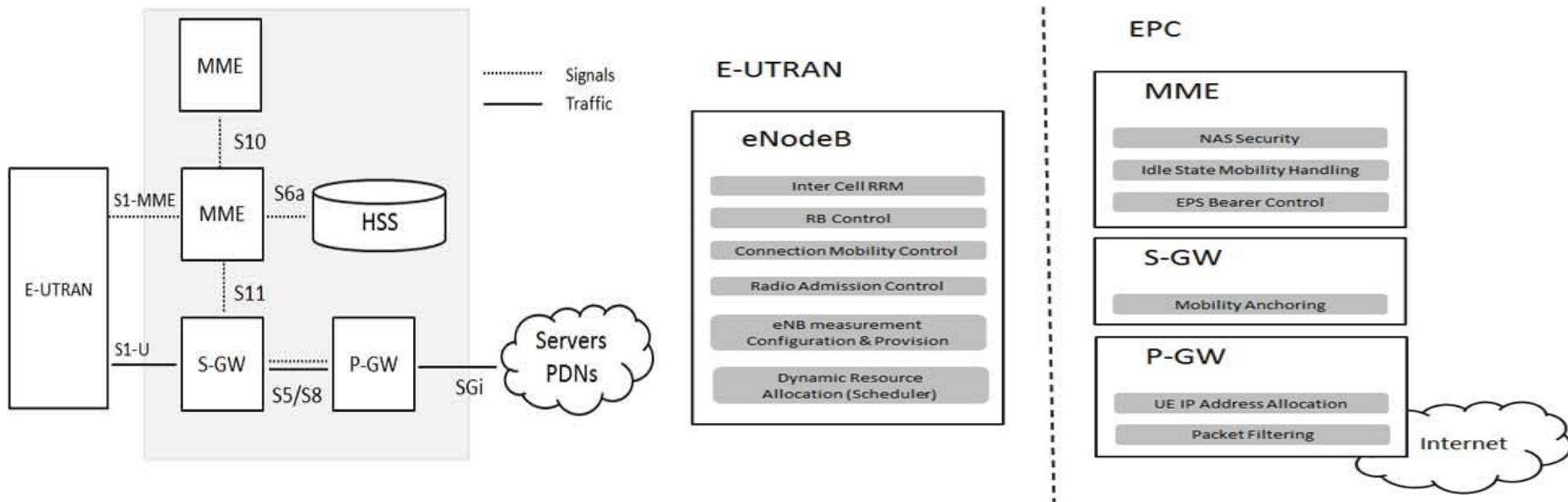


## *Adaptive modulation and coding in cellular systems*

## *Capture and decode FM radio*

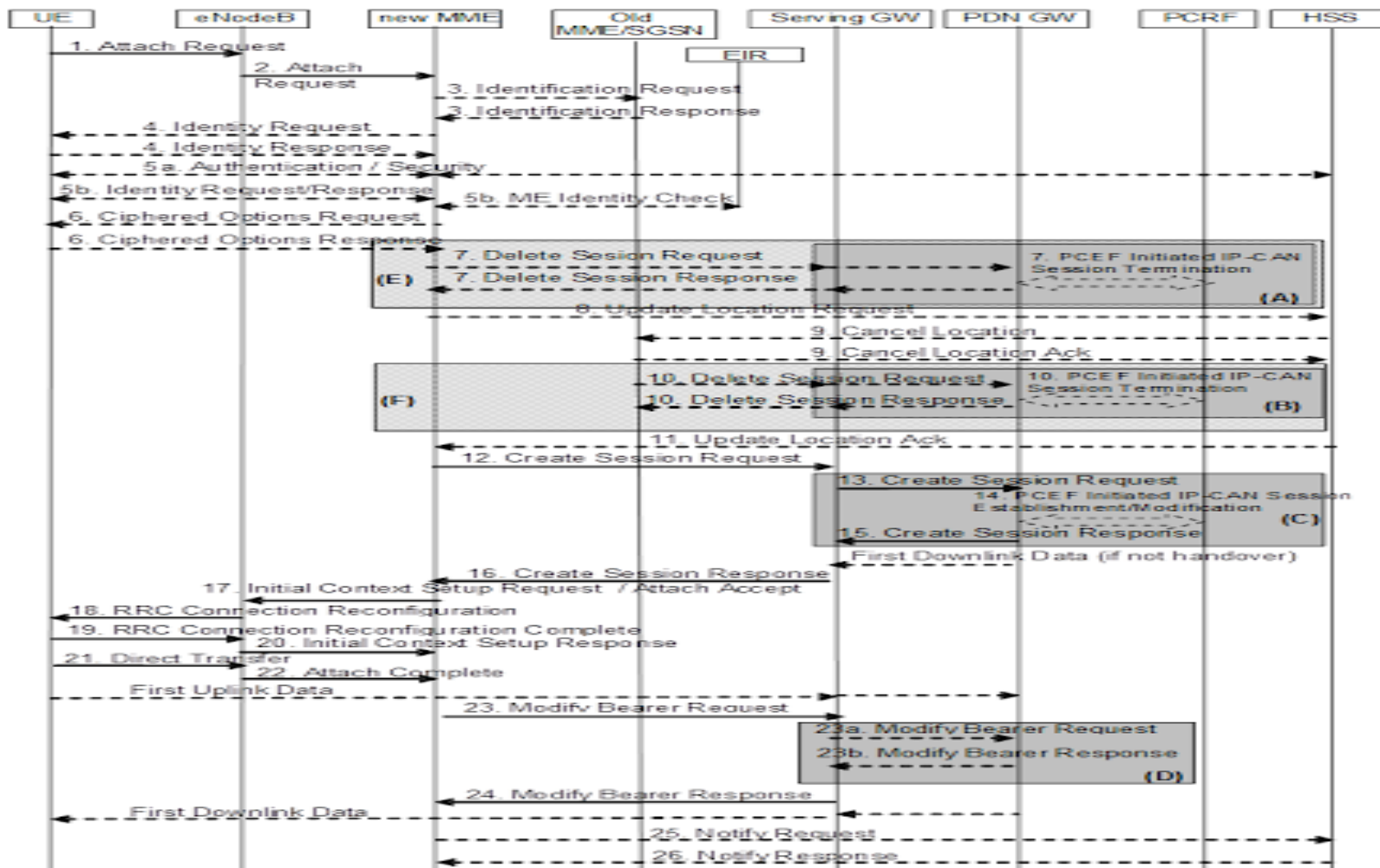
Source: "Run my Experiment on GENI" blog, Fraida Fund, NYU



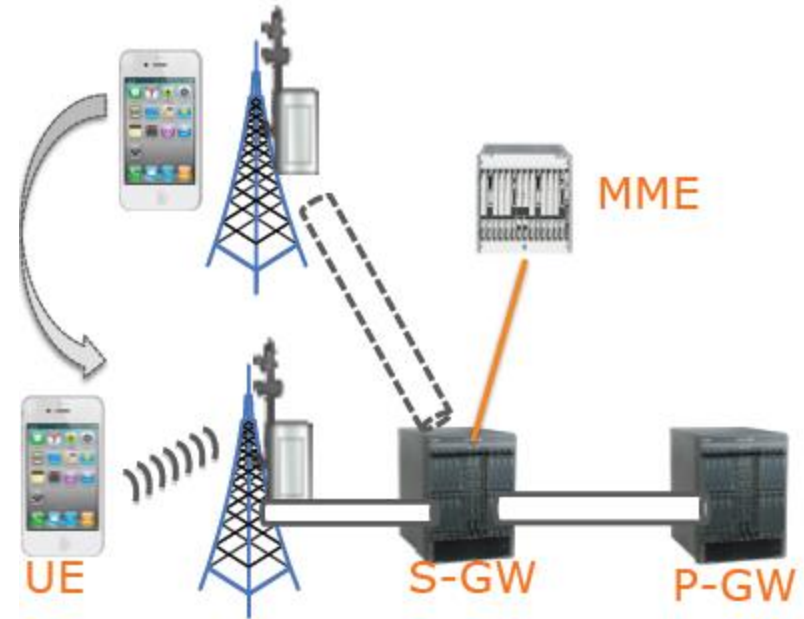


## Components of a LTE Network:

- ✓ eNodeB: Evolved Node B
- ✓ EPC: Evolve Packet Core
- ✓ MME: Mobility Management Entity
- ✓ S-GW: Service Gateway
- ✓ P-GW: Packet Gateway
- ✓ HSS: Home Subscriber Server



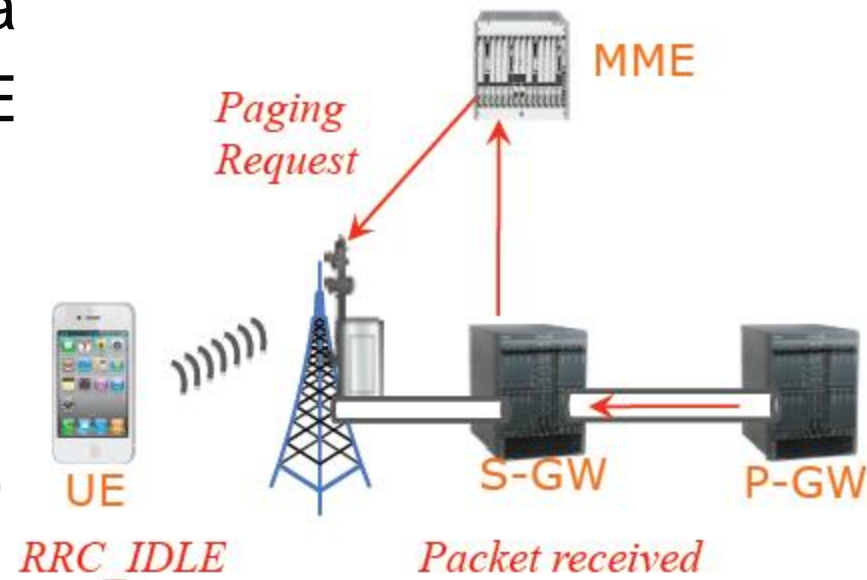
- Handoff without change of SP GW – (S1 handoff)
- Results in up to **33 control messages** in total across SGW, MME and eNBs.
- Handoff with change of S-GW or MME has more overhead



Source: "Rethinking Cellular architecture and Protocols for IoT Communication", KK Ramakrishan, Koushik Kar, Zubair Shafiq

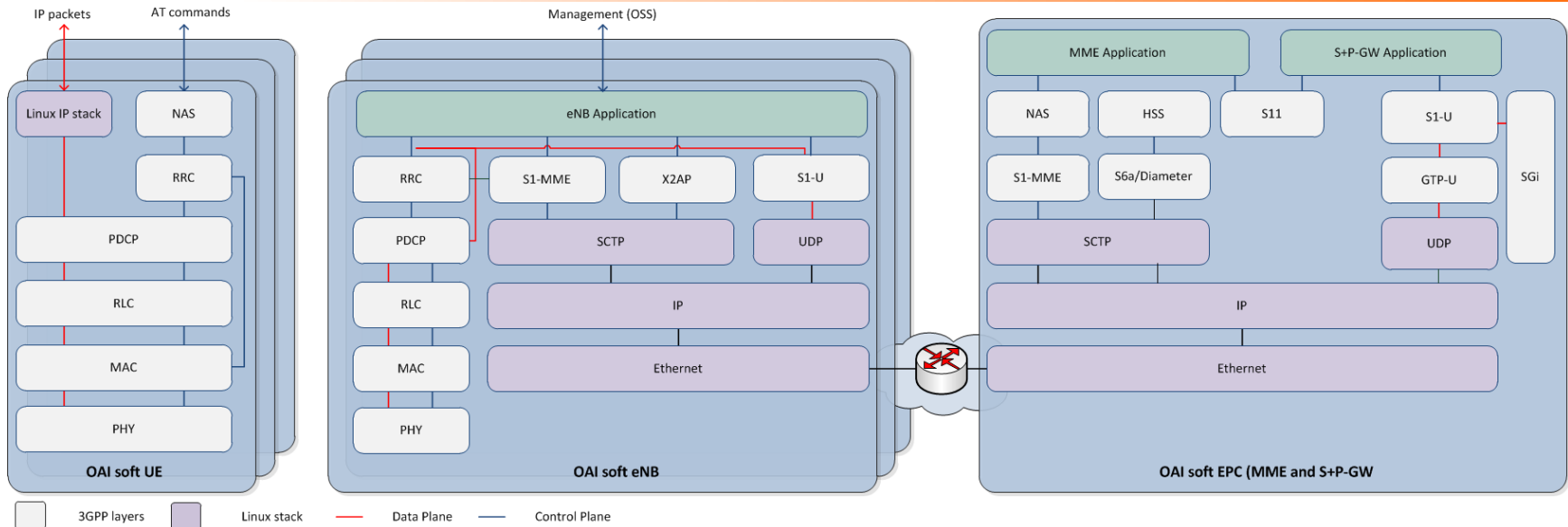
## Paging

- If S-GW receives a packet to a UE in IDLE state, inform MME
- MME pages UE through base station
- Results in **15 to 19 control messages** between S-P GW, MME and eNB



Source: "Rethinking Cellular architecture and Protocols for IoT Communication", KK Ramakrishan, Koushik Kar, Zubair Shafiq

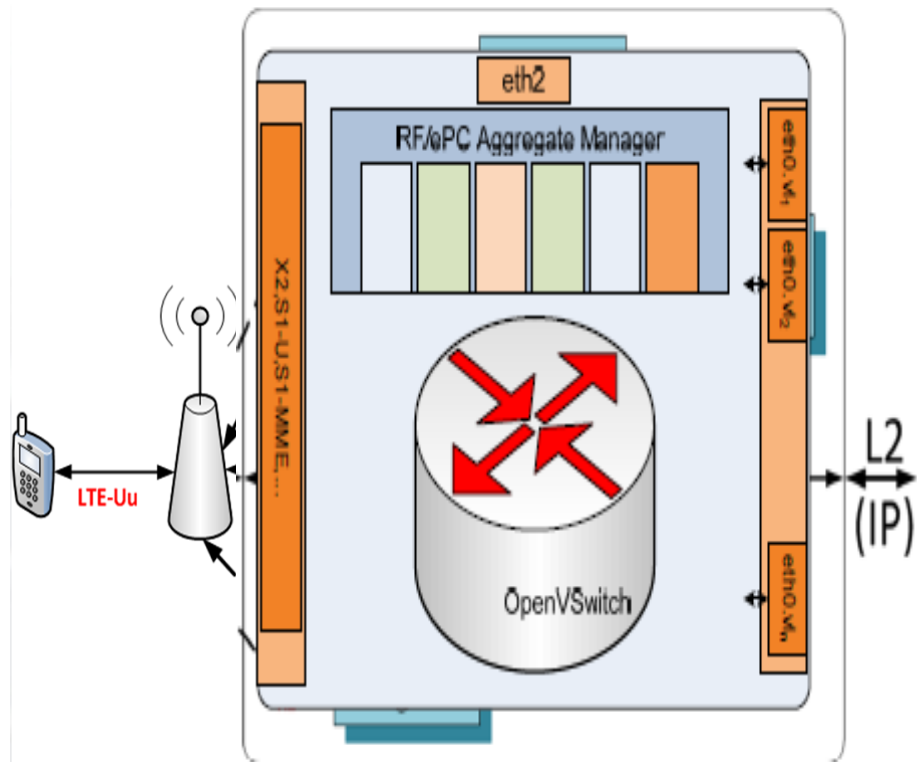
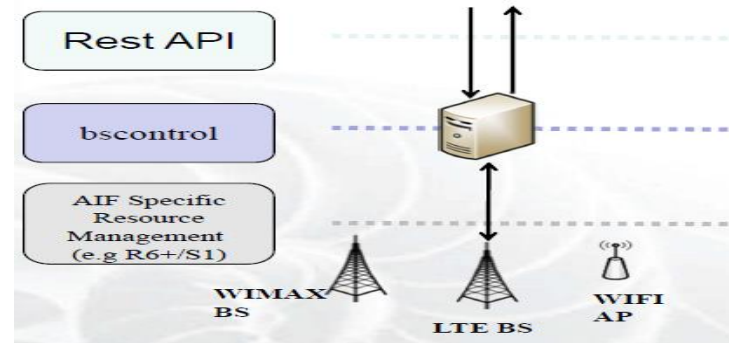
- Deploy GENI Network slicing concepts in EPC by setting up OpenVswitch to map different client GTP (uplink/downlink) tunnel pair to VLAN(s).
- Experimentation with next generation cellular and core network systems ( 5G, Mobile SDN, Cloud-RAN, Virtualized EPC)
- Provide a campus kit for ~\$20K for turnkey access to LTE technology.

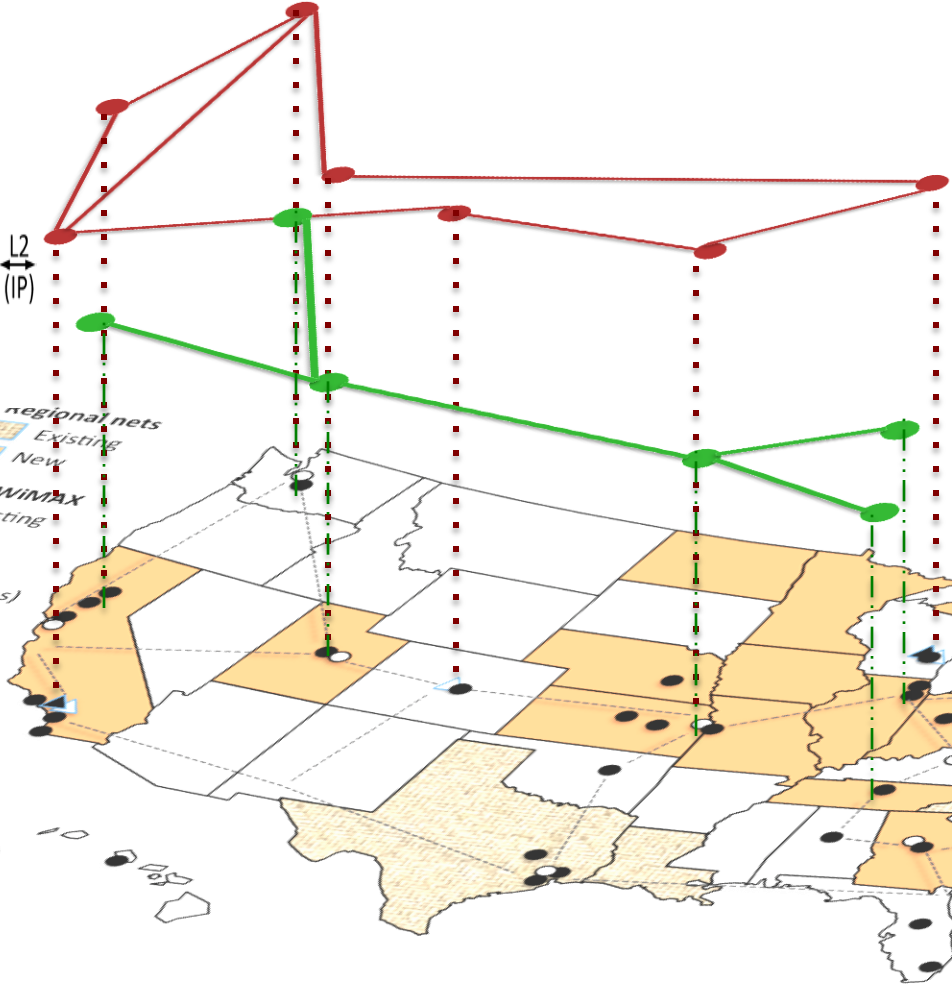
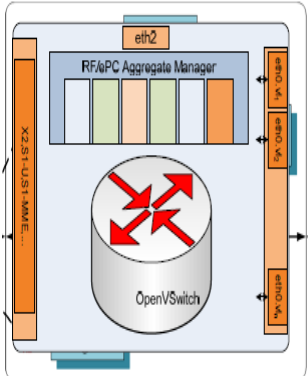


- Commercial UE ↔ OAI eNB + Commercial EPC \*
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- OAI UE ↔ Commercial eNB + OAI EPC \*
- OAI UE ↔ Commercial eNB + Commercial EPC \*
- OAI UE ↔ OAI eNB + Commercial EPC
- OAI UE ↔ OAI eNB + OAI EPC

Courtesy: Navid Nikaein, Eurecom/Open Air Interface

- Bcontrol GENI Aggregate Manager(AM) interfaces L2 VLAN(s) with GTP Tunnel on datapath.
- Implementation using OpenVswitch.
- Northbound REST API based to expose control parameters to experimenters.





Multiple Users ; Multiple GTP; Multiple L2 VLAN



## *4G Base Station Hardware*

### AirHarmony

Located closer to the end user, providing much higher aggregate data rates

TDD LTE

Max Transmit Power: 30 dBm per Tx

2 x 2 MIMO:

Operational Frequency Bands:

7 and 41 (2.6 GHz), 12, 13, 14 and 17 (700 MHz), 20 (800 MHz), 40 (2.3-2.4 GHz), 42 and 43 (3.4-3.8 GHz)





**LG Nexus 5, Samsung Galaxy S4**  
Android 5, AT commands  
Test SIM

## USB Dongles



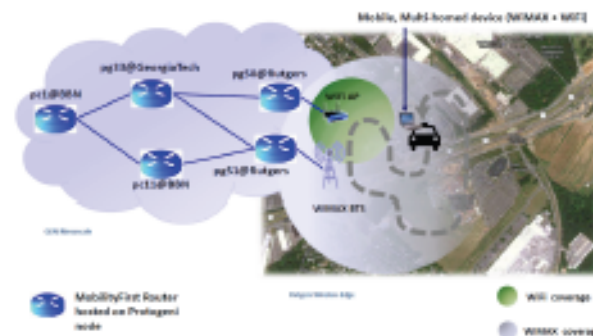
**Netgear 341U, Sierra Wireless,  
Greenpacket LTE CPE**  
Linux Driver  
Test SIM

## MobilityFirst on GENI: Selected Experiments

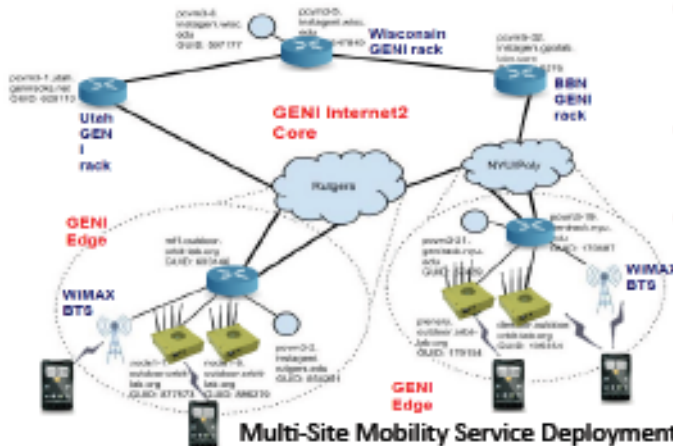
- GENI has been an integral part of MF evaluation methodology since the project started in 2010 ....



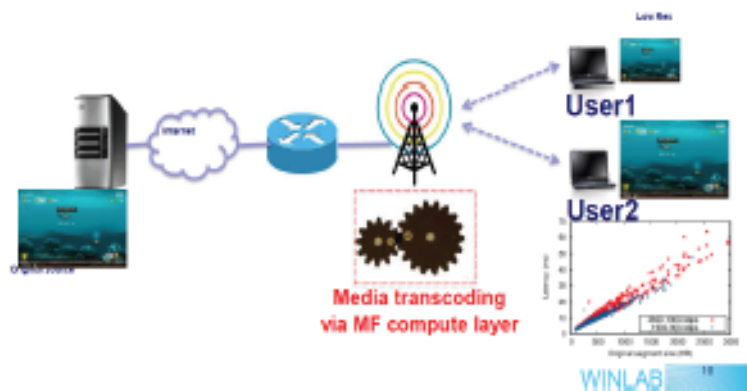
Content Delivery Scenario – GEC-12



Mobility with Dual-Homing – GEC-13

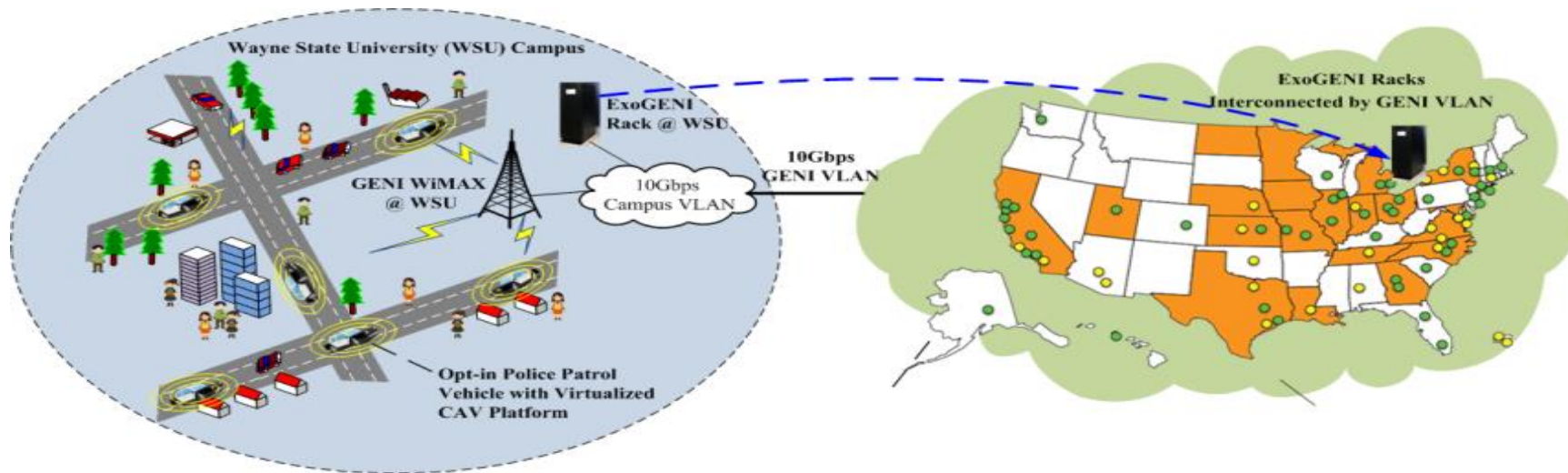


Multi-Site Mobility Service Deployment – GEC-19

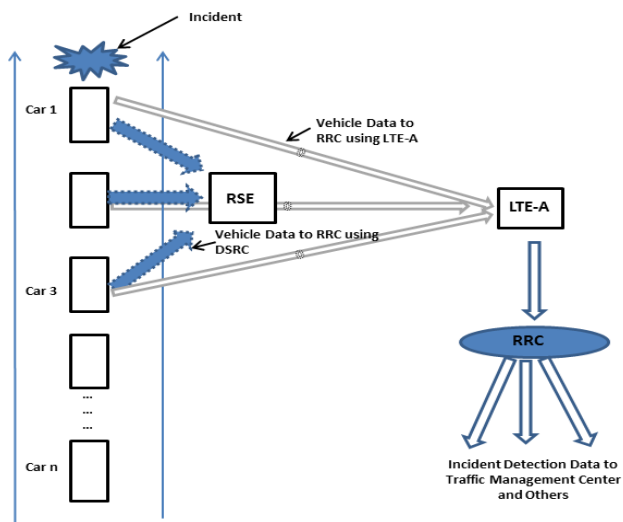


Video Delivery with In-Network Transcoding – GEC-21

\* Dipankar Raychoudhuri, Rutgers Univ.



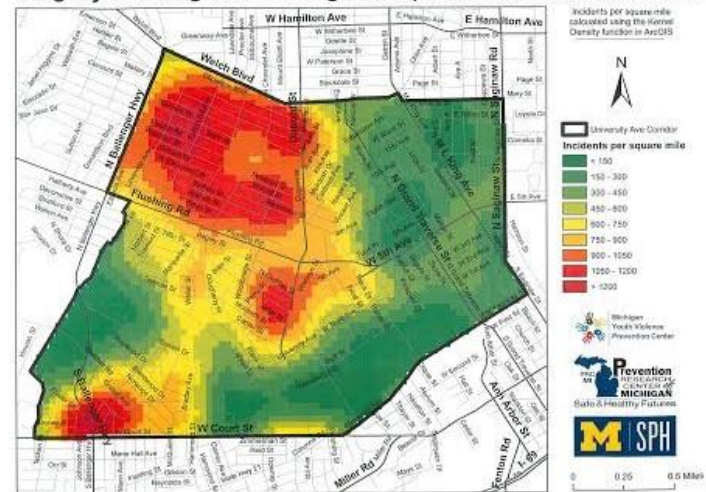
\* Hongwei Zhang, Wayne State University



\* John Geske and Yunsheng Wang, Kettering University

\* Jim Martin and K.C. Wang, Clemson University

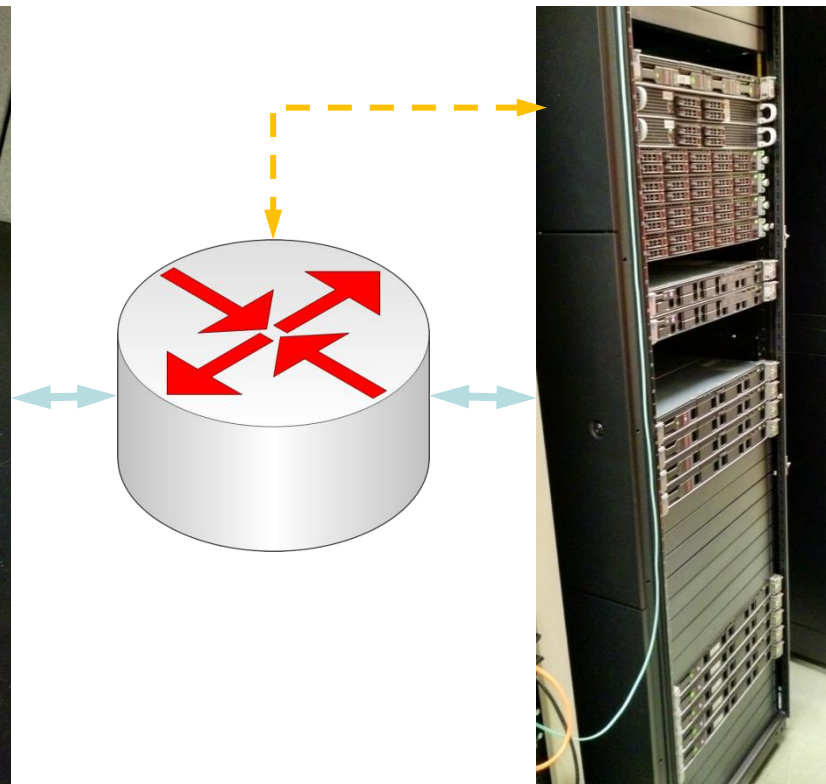
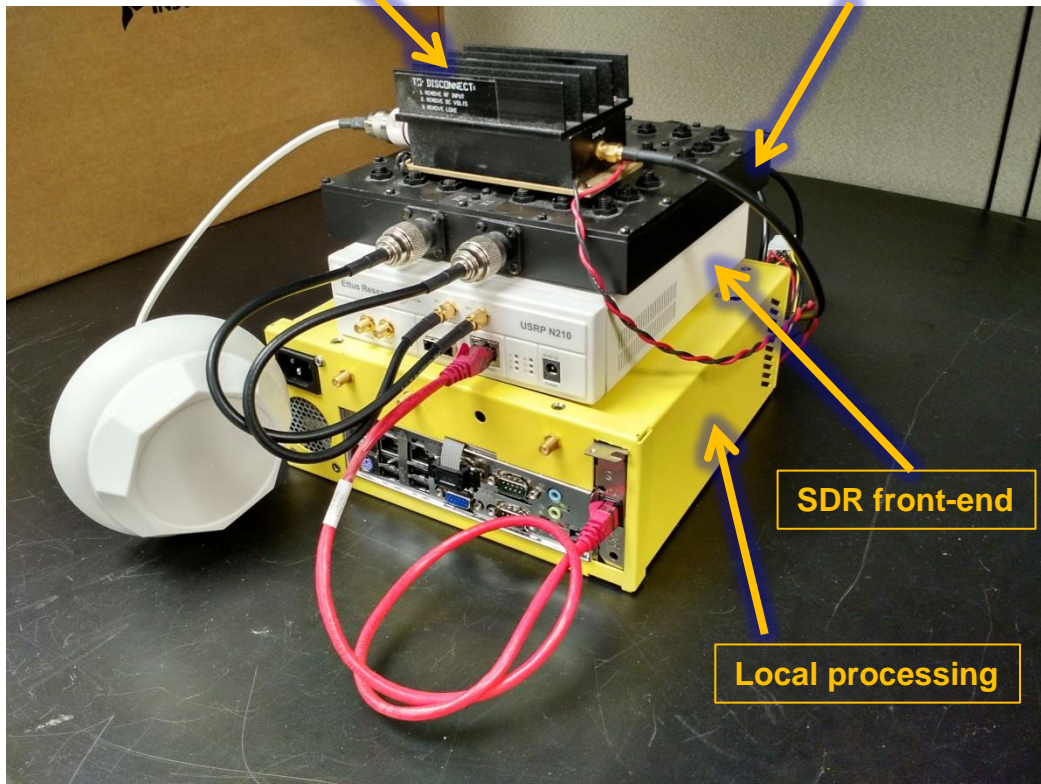
Burglary/Breaking and Entering University Ave Corridor, Flint, MI, 2010 - 2012



Modest power amplifier

RF "Firewall"

GENI Rack



# QUESTIONS



<http://groups.geni.net/geni/wiki/WirelessFGRE2016>