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Things in a Fog (TGIF): A Framework to Support Multi-domain Research in the Internet of Things

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Talk Overview

- Setting the stage
- SC-CVT: South Carolina Connected Vehicle Testbed
- TGIF: ThinGs In a Fog
Setting the stage - Research

• Our prior research focused on performance issues related to Internet protocols and applications in scenarios involving congested access links (cable, DSL).

• Cable access led very naturally to WiMAX – grant was from the DOJ/NIJ to explore usefulness of WiMAX for public safety (4.9 GHz or lower)

• Led to our current direction in heterogeneous wireless networks – initial funding from NSF.
  • Reconfigurable properties of mobile radios
  • Level of cooperation between autonomous wireless systems

• Current status – consider paths for wide scale adoption.
  • How to build large scale wireless hetnets:
    • The granularity of scheduling and control at mobile devices
    • The information that might be available to a regional resource controller
    • Global resource allocation strategy
    • Extensions for the Internet?
Setting the stage – infrastructure

• iTiger – large scale WiFi use at our football stadium
• CyberTiger – wireless broadband assessment
• SciWiNet - build, deploy, evaluate infrastructure to support academic research ‘out in the wild’ - including network measurement ‘services’
  • MVNO(with Sprint), rooted Android smartphones with middleware, co-locate a SciWiNet network control box at Sprint’s facility, programmable access to Sprint’s device and traffic management.

Common themes
• Provide incentives to end users to participate
• Open data repository
• Supportive of our hetnets direction
  • Regional resource controller makes use of contributed performance data
The South Carolina Connected Vehicle Testbed (SC-CVT)

Recent USIgnite grant: “Enabling Connected Vehicle Applications through Advanced Network Technology”

• The project is a collaboration with Clemson’s automotive and transportation faculty and with South Carolina’s Department of Transportation.

• According to the US DOT, Connected Vehicle represents the systems required to support vehicular applications that communicate in a vehicle-to-vehicle or vehicle-to-infrastructure communications mode. This system is defined by a large set of standards collectively referred to as WAVE (Wireless Access in a Vehicular Environment)

• Our project explores the potential benefits of connected vehicle applications that operate in a wireless network that extends the standard WAVE system with additional wireless networks (i.e., a wireless hetnet)
The South Carolina Connected Vehicle Testbed (SC-CVT)

• Extend, develop, evaluate two Connected Vehicle application concepts in a manner that leverages advanced network infrastructure: Queue Warning and Traffic Incident Detection
  • These applications are established ITS applications that analyze traffic flow data and attempts to predict the onset of congestion or to identify an incident.
  • However, CV imposes significant change wrt to volume and accuracy of the data

• We have developed a testbed on campus:
  • Includes three Road Side Unit’s (RSUs) and a dozen On Board Units (OBUs)
  • Each node has at least one additional wireless connectivity option (wifi or LTE)
  • We have developed middleware that support services to support CV application
• **Queue Warning:**
  • The approach is to explore machine learning method to our system
  • Periodic messages (Basic Safety Messages) from vehicles provide the raw information
    • At the RSU, the raw data is analyzed, a reduced set is used by a Queue Warning detection algorithm based on Machine Learning.
    • The reduced data is sent to a regional compute node that handles training data updates.
More broadly…TGIF

We have faced the following challenges
- The deployment location was moved to campus.
- Gap between US DOT architecture and distributed computing systems.
- Difficult to enable advanced networking services to applications.
- A deployment involving three edge nodes with a handful of vehicular does not allow realistic studies.
  - In-the-loop simulation is not quite there.

We opted to broaden the scope to include edge computing in a shared infrastructure model with the goal of promoting the reusability (sharing) of data.

Disclaimer: we are at the early stages of requirements/design/prototyping
**ThinGs In a Fog**

- An IoT Framework that includes application programming environment along with a system architecture
- Set of nodes defines - system, fixed edge, mobile edge, machines nodes that require GW services
- All TGIF nodes run middleware providing applications access to services including:
  - GEO - location, finding nodes within a bounded box, …
  - Messaging – the system is primarily pub/sub.
  - Cx Services - multipath socket, assistance in choosing the ‘best available network’
  - GW - interfaces non-TGIF nodes to the system
- TGIF application interface is C++
  - Object abstraction to allow the applications work on any device that can run Unix.
  - Easy to simulate nodes, mobility, and events
- ‘Third party’ applications will subscribe to data of interest - e.g., analytics engines,
Quite a bit of academic activity in this area ....

- Wireless sensor networks: bottom up
- Semantic Internet: top down
- Similarities with recent Named Data Networking papers

- Our approach:
  - Develop a set of messages with appropriate topics that facilitate the reuse of data
  - Attributes are set by the system or application to give hints about the data:
    - Spatial, locality, lifetime
    - Access rules - we have two rules at this point: open (anonymous available to all users), restricted (to users with a token)
  - Security direction
    - Service (GEO, Msg, Cx) specific
    - Block chain to authenticate ... open issue is defining the trust model