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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 ?

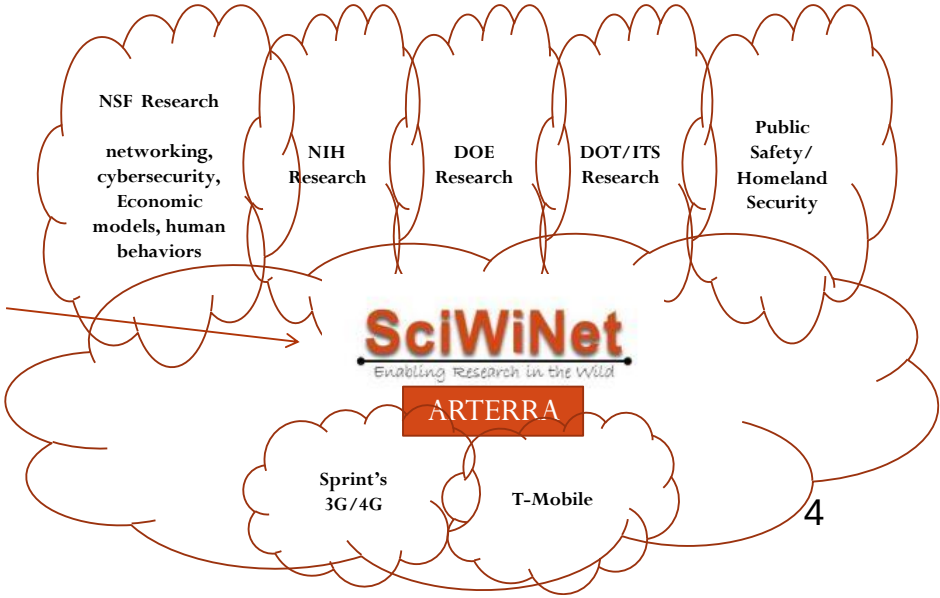
Setting the stage – infrastructure

- 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

SciWiNet is a Mobile Virtual Network Operator (MVNO)- our users are the academic community



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)

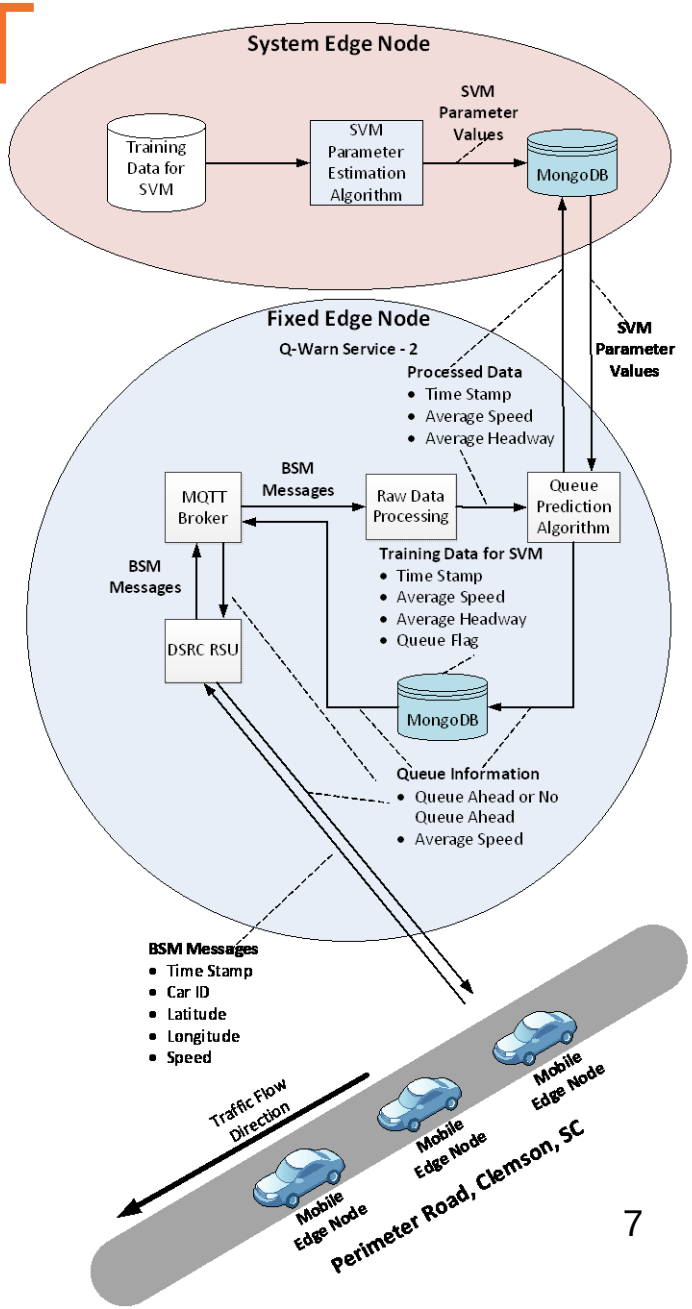
The South Carolina Connected Vehicle Testbed (SC-CVT)

- 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

SC-CVT

- Queue Warning:
- The approach is to explore machine learning method to our system
- Periodic messages (Basic Safey 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

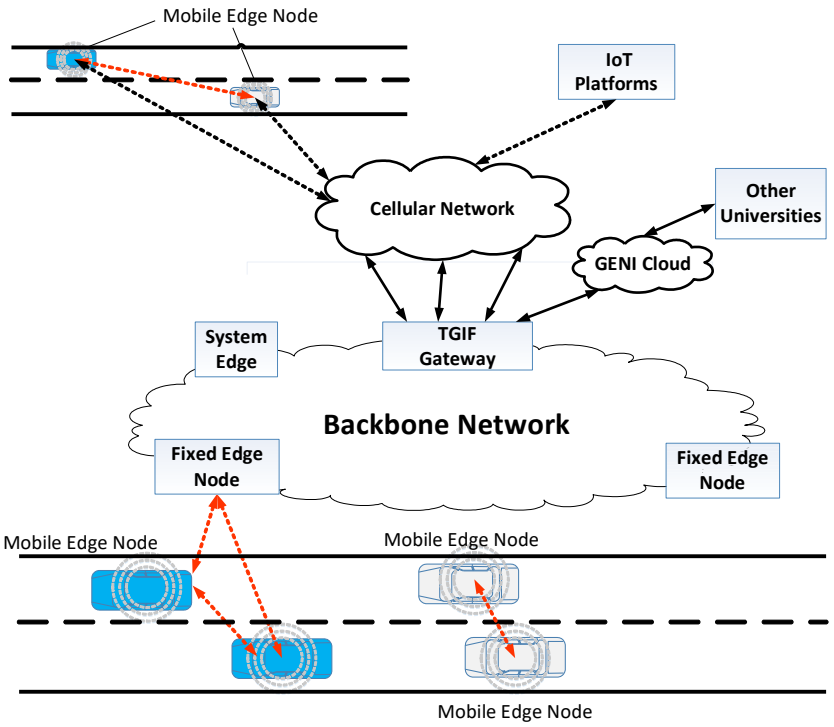
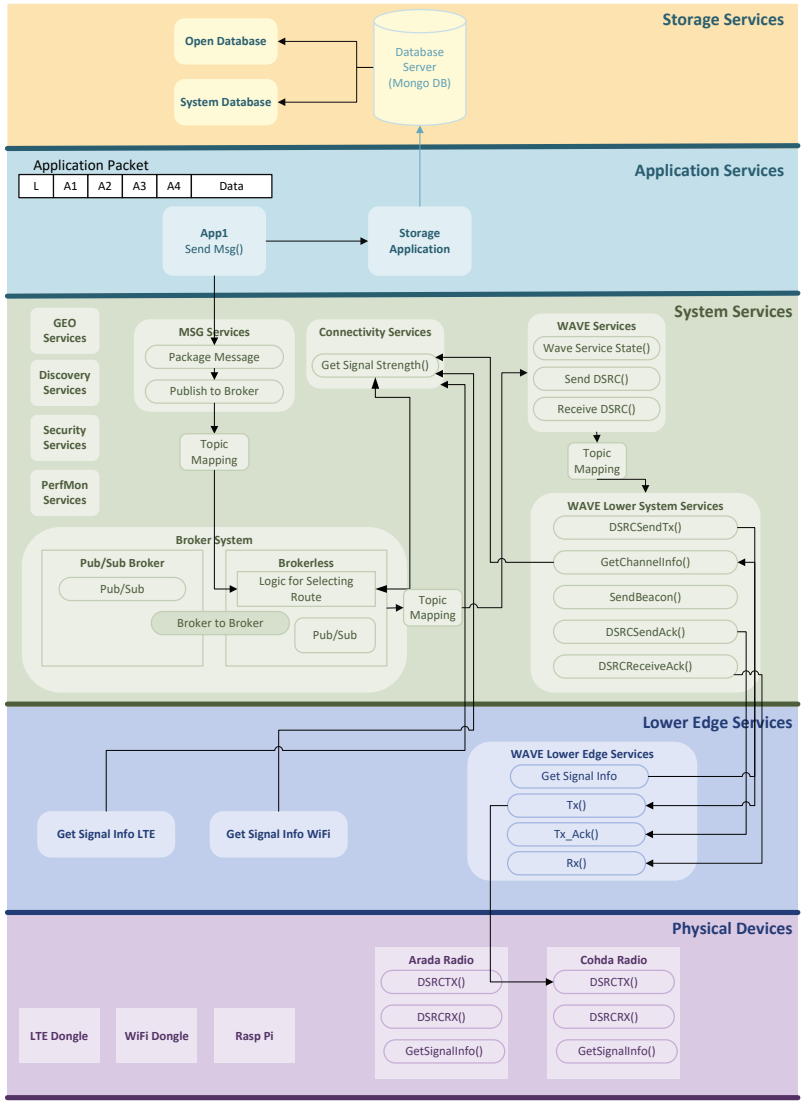


Fig. 1. TGIF system architecture.

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,



ThinGs In a Fog

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