CB MANET Performance Characterization Tools

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Abstract

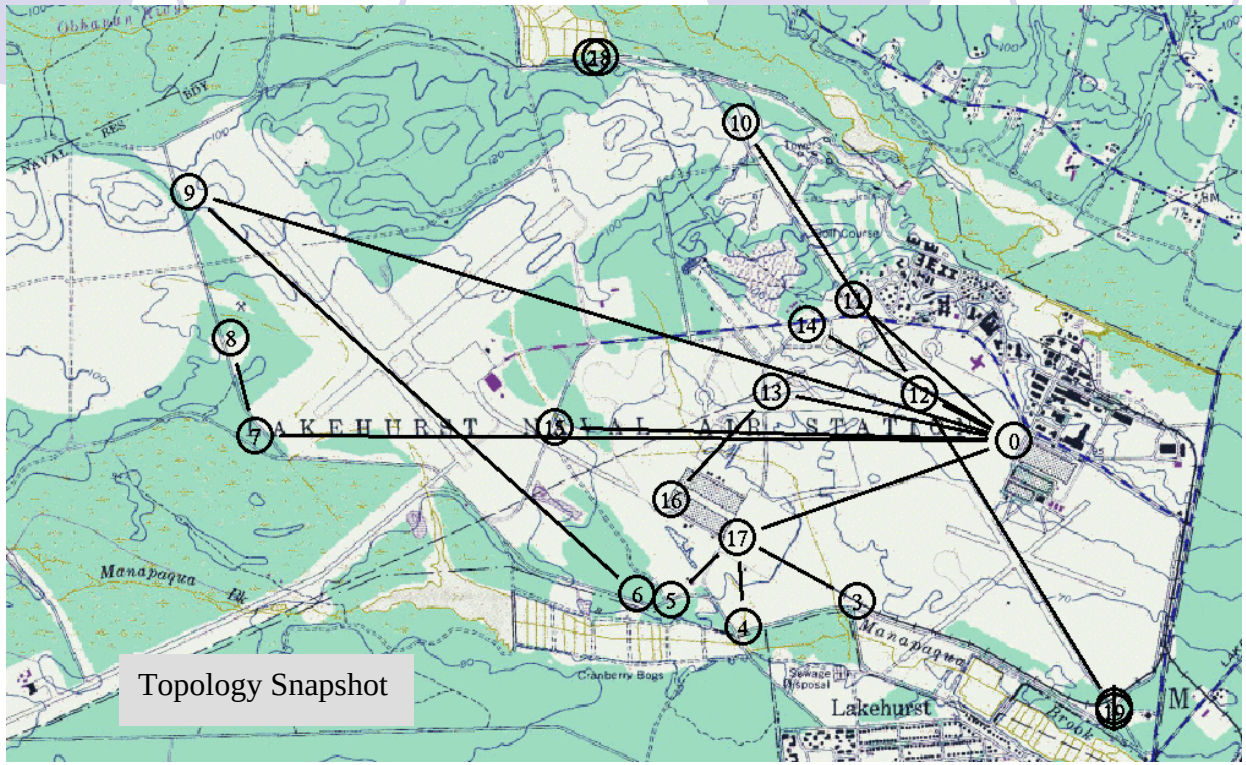
- The complexity of network-based communication systems requires thorough, detailed performance evaluation and characterization to determine suitability for critical, tactical systems.
  - *Subtle protocol interactions can potentially lead to pathological conditions in dynamic, often stressed tactical communication environments.*
- Some test tools and methodologies are available that have already been successfully deployed in a variety of field experiments.
- It is DARPA's intent to use, extending as needed, the available technology to the field characterization portions of the CBMANET program.

Background

- NRL has conducted research and development of MANET and other network technologies (reliable transport, multicast communication, IPv6, security, etc) for many years.
- NRL developed numerous tools and prototype software to support these R&D initiatives*.
- These unique capabilities led DARPA to seek NRL assistance in both setting a performance baseline for *and* evaluating the performance of candidate Future Combat System (FCS) tactical networks technologies under the FCS-C and other programs.
- NRL has continued to mature its toolset in ongoing DARPA, ONR, and other projects including extensions to support simulation, emulation, and field testing.

(*See http://cs.itd.nrl.navy.mil)

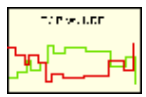
DARPA FCS-C Lakehurst Demos



- Supported baseline testing for FCS-C Phase 1
- Used NRL version of MANET OLSR routing to establish omnidirectional performance baseline
- 20 mobile vehicle nodes
- Roofmounted mobile antennas and 5W power amp extended range of existing 802.11 technology

NRL Test and Analysis Tools

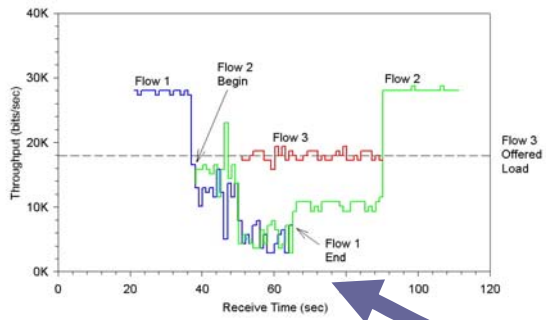
- Test and Instrumentation
  - MGEN - message generation (and reception) tool for unicast, multicast, QoS, etc. (UDP, TCP, and “other”)
  - RAPR - adds “causal” behavior modeling to MGEN capability
  - Network trace tools
  - Wireless Sniffing and Measurement Tools
- Analysis Tools
  - Trace Plot Realtime (TRPR) compatible with MGEN, tcpdump, and ns-2 trace files.
  - Data Analyzer (dazle)



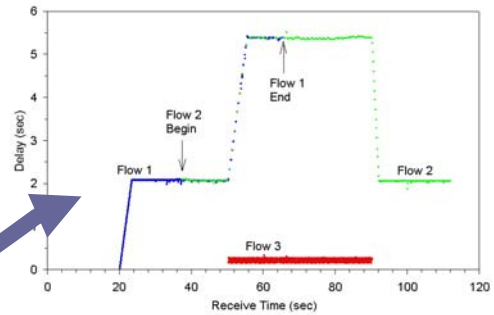
- Methodologies
  - Scenario generation, data collection, etc to support these in simulation, emulation, and field environments.

MGEN End-to-End Testing Examples

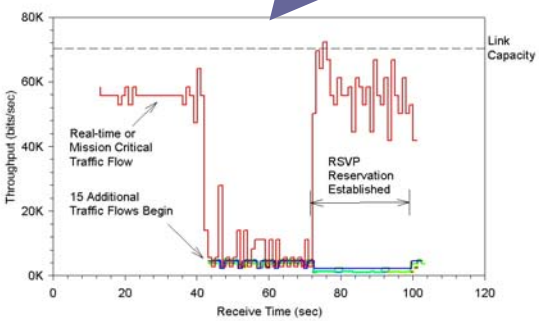
Cisco Custom Queueing (i.e.,WFQ) Test Example (Throughput)



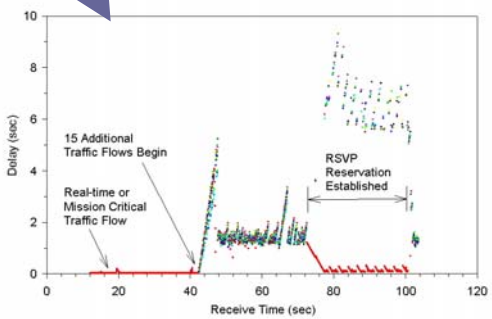
Cisco Custom Queueing (i.e.,WFQ) Test Example (Delay)



RSVP/WFQ Test Example (Throughput)



RSVP/WFQ Test Example (Delay)

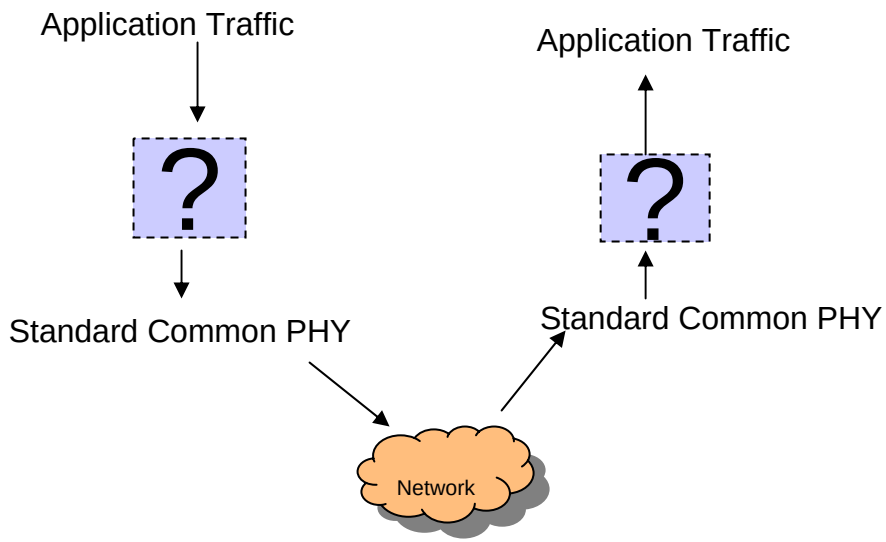


MANET Performance Characterization

- Historically, the focus has been on first order metrics of network loading, goodput, latency, and sometimes quality-of-service (QoS).
- However, application performance is not always a direct function of these metrics.
- And, other network design factors will affect system effectiveness:
  - Wireless network join times
  - Auto-configuration behaviors
  - Security authentication performance and impact
- The network's ability to adapt to changing needs in QoS for different applications as tactical missions progress should be considered.
- The paramount metric is a measure of the network and applications ability to meet mission needs.
- This depends upon network applications and how they behave and respond, particularly as we deploy more distributed systems with increased autonomy.

CBMANET Program Objectives:

- Replace/Rethink OSI Protocol Stack
- Demonstrate Improved ETE System Performance
  - Metrics Next chart
- Go/No Go Demos
  - Fix Standard PHY
    - Freq Band(s)
    - Emission Bandwidth
    - Power/Antenna
    - Modulation
  - Defined Application Layer traffic
    - SA/C2 data (file size)
    - Voice Calls (duration, frequency of occurrence
    - Video Streaming (frames per sec, resolution)
    - Imagery (file size, resolution)
    - Point-to-point and one-to-many
    - Not yet packetized but still discrete
- Combined Field Testing and Modeling and Simulation



How the CBMANET Problem Differs

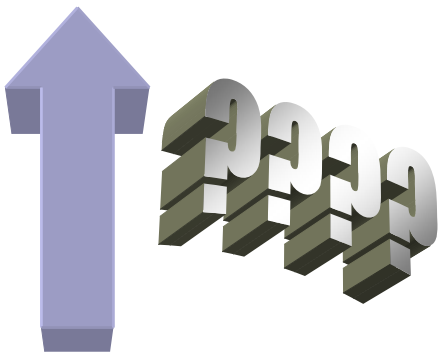
- We can't peer inside the "Network Black box"
- We need to generate application layer traffic streams not IP packets
  - *(We can't even be sure there will be IP packets)*
- We need to associate QoS/Priorities with flows and messages

How Do We Measure Network Effectiveness?

Network Effectiveness

Call for fires delivered on time
Accuracy/Currency of SA picture
Intelligibility of Voice Comms
Resolution of Video

Warfighter Needs



How do we analyze network metrics to determine network effectiveness?

Network Metrics

Latency
Throughput
Message Completion Rates

Measurable Parameters

What Network Effectiveness is Not

- NE does not by itself determine true “mission effectiveness”
- NE does not measure damage to the enemy or to friendly forces
- For our purposes, it is assumed that if the network is effective, then the mission success if positively impacted:
  - A full scale simulation which would measure overall mission effectiveness is beyond the scope of this effort
- Bottom line: We need metrics we can effectively measure in the field and methodology for translating measured metrics to network effectiveness.

So What Do we Plan to do Differently?

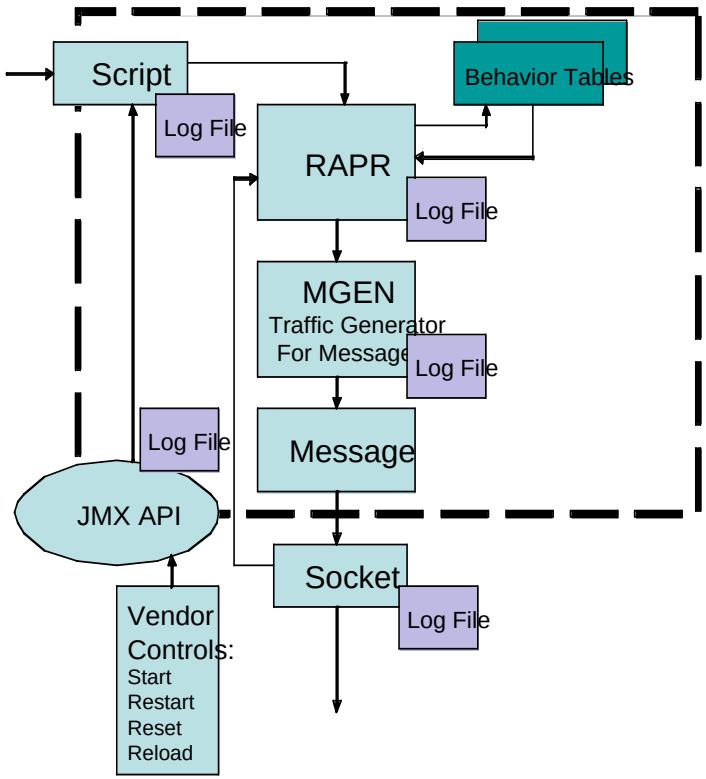
- The tools used in the past have been developed to provide IP packet flows, both for pre-determined traffic loadings, and, more recently, to dynamically model application behaviors.
- These tools can be adapted to generate “messages” where:
  - Generated “messages” can correspond to messaging some applications might do, but also
  - Represent bulk content transfers (files), or
  - Real-time communications (voice, video, etc), and
  - Signaling (connection establishment, call setup, etc)
- This could be an incremental extension to the current NRL tool set.

Network Application Layer Modeling

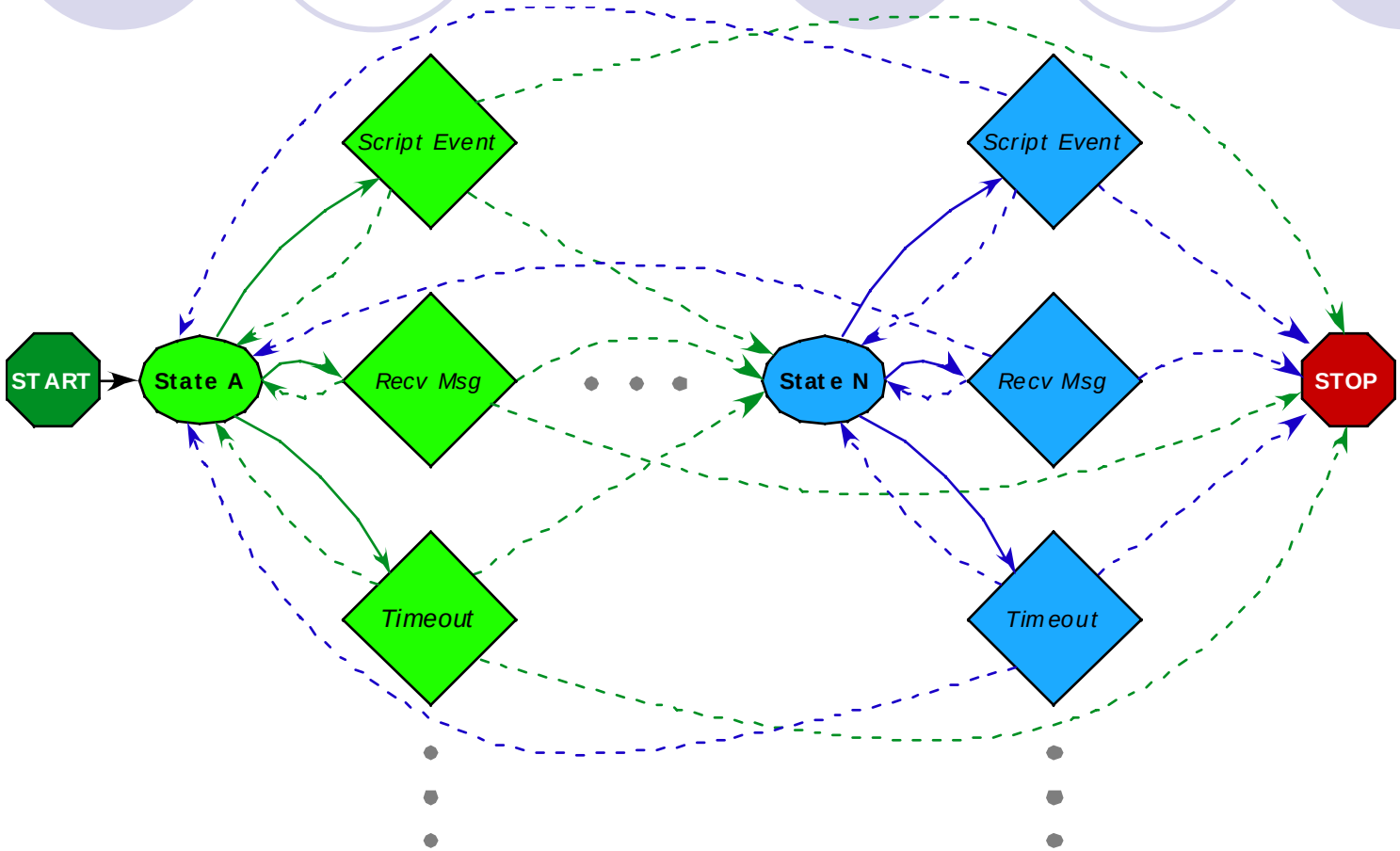
- NRL's RAPR (Runtime Application Representative) is a scriptable tool that can be used to model application behavior including causality of communication transactions, etc.
- Based on MGEN code base (uses *Protolib*) and imminently portable into simulation environments (OPNET, ns-2, etc) as well as supporting emulation or field testing.
- Provides proxy content that lends itself to detailed performance analysis. Analysis tools are in development.
- Current efforts including modeling of notional applications and their behaviors:
  - VoIP
  - Video Streaming
  - Logistics
  - Command and Control Data
  - Intelligence dissemination

Application Behavior Modeling

C4I Application Module Components



RAPR States & Events



The RAPR “Behavior Tables” will describe each state, its actions, and transition behaviors and probabilities.

Application Behavior Modeling

- Some core application behaviors will be represented:
  - Data transfer/exchange (bulk/reliable, real-time, messaging, etc)
  - Connection establishment (or “call setup”)
  - Resource discovery (as applicable)
  - Group communication
- Causality will be modeled:
  - E.g., if connection/call setup fails, re-attempts will occur, on success data transfer/exchanges will proceed
  - Data exchange transactions will be modeled with semantics for repeated attempts upon failure, etc
  - Network services (discovery, name resolution, etc) will be invoked as appropriate and needed.

Simulation & Modeling Environment Support

- The NRL tools use a cross-platform toolkit (*Protolib*) for timing and input/output (I/O) that has also been adapted to simulation environments (ns-2 and OPNET)
- Thus, the application behavior emulation and message generation capabilities of the test tool set can be introduced into simulations
- Need to coordinate this with the OPNET M&S Team

CBMANET Test & Evaluation System

- Even with flexible, capable components (e.g. MGEN, RAPR, etc), a system is needed to support moderate to large scale test scenarios (lots of nodes, lots of data to collect)
- This is similar to past NRL efforts where the “Nettion” test tool integration framework has been used to implement scenarios, coordinating test tool scripting, data collection, and analysis.
- Some refinements will be required to meet specific CBMANETgoals.

Data Analysis

- Data analysis tools will be used to quantify performance of baseline reference system.
- The same data analysis will be conducted to compare the performance of vendor technologies against baseline reference.
- Measures of effectiveness are still in development. As possible, these will be aligned to measure the degree of successful execution of notional IER threads used to represent operation requirements.

Conclusion

- Development of robust, effective, complex network systems requires an integrated effort consisting of both simulation and field testing.
- Dynamic tactical networks will provide a widely varying range of communications quality for differing applications.
- Network protocol and application behavior, plus response to possible dynamics, are critical parts of total system design.
- **It is possible to take a “Black Box” approach to the effective performance characterization of MANET networks.**