NETWORK-CENTRIC APPLICATIONS
AND TACTICAL NETWORKS

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8th International Command and Control
Research and Technology Symposium
17-19 June 2003
Washington, DC
Tactical Networks

• If you have ever worked with Tactical networks
  – Quickly realize
    • Do not match wired networks in
      – Throughput
      – Reliability / packet delivery (loss) / connectivity
      – Are highly mobile
  – They are the mainstay of warfighter connectivity
    • Recent experience shows the benefits, and cost, of having (or not having) reliable tactical networks
      – Knowing where your friends are is very important in fast paced hostile environments
        » Prevents you from being fired on, allow you to fire / react more quickly

• Nearly unimaginable we would consider a fast paced large or medium scale military action without the deployment of tactical data networks
  – They are, to an every increasing degree, becoming a critical part of modern warfare
Tactical Networks

• Mostly discussing mobile networks used by warfighters on the pointy end of the spear
  – Wireless, mobile, ad hoc, often air borne relay based, on-the-move, over-the-horizon

• Not discussing Command Post large scale SATCOM type configurations
  – If it arrives on 10s of trucks and takes days to establish, it doesn’t meet the threshold for this discussion
Tactical C2 Apps

• Are the critical component that bring functionality to the applications
  – No one cares about communications without C2
  – However, you can’t “command and control” without communications

• At user (warfighter) level these systems have always been linked

• GCCS, C2PC, FBCB2, AFADTS
  – Well know “C2” applications in “common” use by warfighters
    • All used in Iraq Freedom
  – None define a communication path
  – All are intended to operate over “network of opportunity”
    • In many cases, they simply don’t
      – Or at least have lots of room for improvement
Network & Applications

- System approach – combination of Apps and network is the “problem”
  - To date we (developers of apps and networks) have done poor job of recognizing and adapting to limitations of the other
  - Result has been rather marginal performance of these systems
    - Rarely do warfighters believe C2 systems meet their requirements
    - Even when they believe C2 systems meets requirements – they “blame” comms system for poor performance and resultant poor C2
Network & Applications

• “We” must advance the current state of the art
• Next big strides will be made when application developers accept and compensate for “deficiencies” in tactical comms
• Tactical comms will improve, but
  – They will never be ubiquitous
    • There will be total comms outages and sometime they will last for minutes or 10s minutes
  – They will never have enough throughput
  – They will never have packet delivery approaching wired networks
Network & Applications

- Tactical networks currently have and will (likely) evolve to support
  - Packet loss on the order of 20-40%
    - Over a several minute average
  - Throughput on the order of 10s Kbps to/from each “major” node
    - Some key nodes will be higher, perhaps much higher, but C2 apps should be designed for the lower end, not the extremes
  - Total comms outages from few minutes to 10s minutes pretty “routinely”
  - Be very heterogeneous in nature
    - Don’t try to model any one radio / network approach it isn’t necessary
    - Instead, focus on basic “services” network provides
      - Build C2 applications tolerant of the services that can be provided
We Are Comms Guys

• Realize some in comms community disagree with our summary performance assessment, however
• We have lots of data to suggest we are “reasonably” accurate
• See no major “break through” in technology that will substantially change them
• Believe them reasonable enough to encourage their use by application developers
  – Guarantee they are much closer to reality (past, present, future) than developing on a wired Ethernet
ELB ACTD Architecture

Figure 1
ELB ACTD Technical Architecture

JOA 200nm x 100nm

Tier 1 – Wavelan
  “subnet”
Tier 2 – VRC-99
  NTDR
Tier 2 “subnet”
Tier 3 – TCDL
  (pt. pt. link)

- Seamlessly interconnected via Routers
- All nodes highly mobile
- Network dynamically reconfigures in real-time

Figure 2
June 19, SYSCON truck to 79N

Overall packet loss 27%.

Figure 3
overall packet loss 13%

Figure 4
02/24/2000
WaveLAN Testing
Racetrack
Bot 4 Patch, 9,000 ft, 62M

Figure 5
Figure 6
Ramp, 1000 byte Pkts, Air 20 nm, Partial Build, 62-500 Pkts/sec
Numerous Results

- Numerous demonstrations / test support basic network performance numbers
- Army / DARPA Future Combat System Lead System Integrator Scalable Mobile Network
  - Winter 2003
  - New Jersey
- Ongoing testing by ONR (LC FNC) at MCTSSA
- Data in paper
Recommendations

• Build applications on networks “comparable” to tactical networks
• Use simulators *all the time* in application labs
• Remain aware of “trends” in tactical networking that could change the “guidance”
• Do not attempt to account for every minor nuisance in radio / network performance
  – *Build to the general performance characteristics of a heterogeneous network*
  – *NOT to the specifics of any one approach*
    • Radio / networks and applications should develop utilization abstraction
    • Expect radio / network protocol to change and evolve
    • Should not adversely impact applications
      – If it does it was a poorly designed application
ELB Application Test Network

Two Clouds Running in Parallel

Figure 8
ELB (and other)

• To large extent single biggest contributing factor to success of ELB was “forcing” application developers to develop / test using network simulators

• Application developers rarely had access to “real” network
  – Proved not to be a limiting factor
  – Was not needed – simulators proved to be wholly adequate and allowed applications and network to develop in parallel
## ELB (and other) Settings

### Cloud Settings

<table>
<thead>
<tr>
<th>Cloud Parameter</th>
<th>Baseline</th>
<th>Worst Case</th>
<th>Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bandwidth Limit – end-to-end (across Simulator, no limits on AP to EUT connection)</td>
<td>80 kbps</td>
<td>80 kbps</td>
<td>240 kbps</td>
</tr>
<tr>
<td>Latency – normal distribution (end-to-end)</td>
<td>Avg = 1000 msec</td>
<td>Avg = 2000 msec</td>
<td>Avg = 1000 msec</td>
</tr>
<tr>
<td></td>
<td>Std Dev = +/- 50 msec</td>
<td>Std Dev = +/- 1000 msec</td>
<td>Std Dev = +/- 50 msec</td>
</tr>
<tr>
<td>Link Fault – BER</td>
<td>10E-7</td>
<td>10E-7</td>
<td>10E-7</td>
</tr>
<tr>
<td>Link Fault – Network Disconnection</td>
<td>Avg. Freq of occurrence = 10 min</td>
<td>Avg. Freq of occurrence = 10 min</td>
<td>Avg. Freq of occurrence = 10 min</td>
</tr>
<tr>
<td></td>
<td>Range of disconnect time = 20 sec – 1 min</td>
<td>Range of disconnect time = 30 sec – 5 min</td>
<td>Range of disconnect time = 5 sec – 20 sec</td>
</tr>
<tr>
<td>Packet Loss – Random Loss</td>
<td>20% loss</td>
<td>30% loss</td>
<td>10% loss</td>
</tr>
</tbody>
</table>

Figure 9
Summary

• Warfighter advances require the closer connection of C2 and comms for next big advance
• Don’t develop for or in “perfect” comms environment
  – Comms guys can not now nor ever be able to deliver it
• Develop using network performance specs, not particular radio / network types
• Data does exist to help develop a reasonable set of performance metrics to develop too