



Investigating the Feasibility of Service-Oriented Architecture with Handheld Computing Devices in Tactical Environments

Problem

Through increasingly sophisticated but often special-purposed devices, warfighters on patrol are now or will be soon linked into their communications network as information gatherers and users and as recipients of situational awareness data. Warfighters—as well as emergency first responders and others operating in similar resource-poor environments—need reliable, real-time access to mission-critical information without the addition of (and weight of) multiple, special-purpose devices.

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Approach

Carnegie Mellon University[®] Software Engineering Institute (SEI) researchers and others have recognized that the combination of two available technologies might place mobile software applications in the hands of warfighters in the battlefield.

These researchers are investigating whether characteristics of the service-oriented architecture (SOA) paradigm and commercial handheld computing technology can be applied to tactical environments. The SOA paradigm provides a standardized interface format for the exchange of information, simplifying platform-to-platform interoperability. Also, commercial handheld computing technology, in the form of smartphones, offers portability, light weight, and support for voice, text, image, and video data.

SEI researchers are investigating

- an emerging architectural paradigm that employs lightweight, handheld devices to provide situational awareness information to edge users such as soldiers and first responders and allows them to provide information back to base
- whether service-oriented approaches employing Extensible Markup Language (XML) and SOAP are viable in light of the potential

limitations in tactical environments, especially resource scarcity on smartphones and low network bandwidth

- whether reasonable quality of service for performance and security could be delivered on commercial handheld devices using existing service-oriented principles and open source off-the-shelf implementations

Experiment Design

The SEI team implemented a series of prototypes to test the viability of using service-orientation (via SOAP-based web services) and mobile handheld technologies (Android mobile computing stack) to access information from tactical assets, including unmanned aerial vehicles (UAVs), and to use this information to enhance the situational awareness of warfighters.

The prototypes were developed in the SEI RTSS¹ Concept Lab environment in Pittsburgh, Pennsylvania using existing technology, standards, and open source implementations. The prototypes were tested at the USSOCOM-NPS Field Experimentation Cooperative Capabilities Based Experimentation (CBE) lab at Camp Roberts, California.

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¹ RTSS is the Research, Technology, and System Solutions Program.

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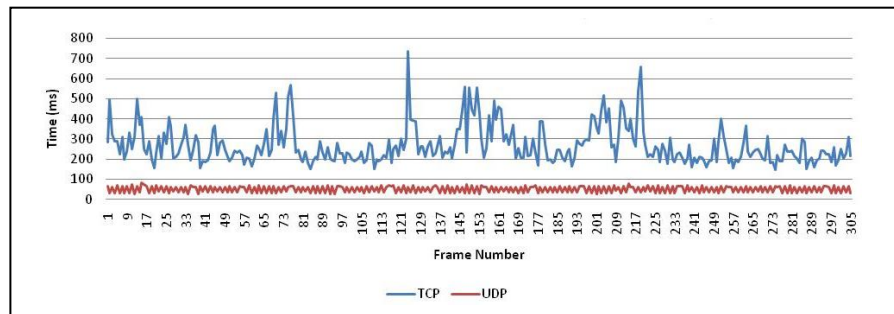
From the experiments, the team gathered performance data on the prototypes concerning

- overhead incurred by the transformation of data from tactical assets (e.g., sensors, UAVs, etc.) into SOAP messages and the parsing and decoding of these messages by the smartphone
- comparison of the performance of SOAP messaging over TCP and UDP protocols to provide real-time video feeds to a smartphone
- overhead involved in smartphone to smartphone SOAP messaging using an intermediary for routing
- overhead of support for network- and application-level security appropriate to the target environment

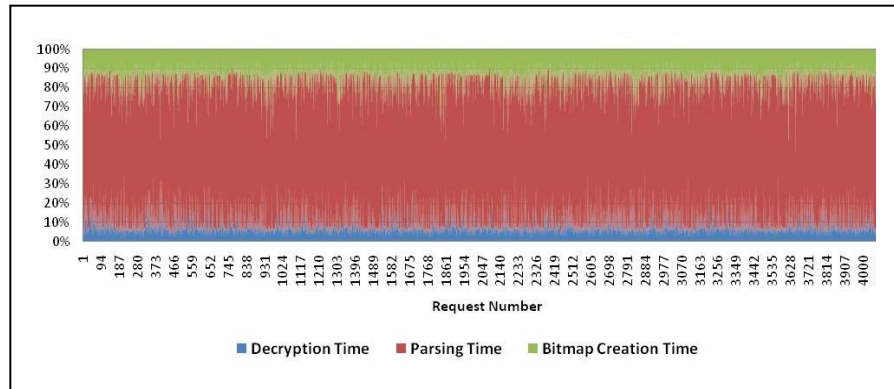
Analysis

A subset of SOA is practical in tactical environments—performance of video feeds (using SOAP-based messaging) displayed on the smartphone is comparable (visually) to video feeds displayed on standard desktop machines. However, the use of SOAP leads to large message sizes that may be problematic in networks with highly constrained bandwidth. In addition, to make SOA practical, the SEI team made atypical SOA choices, including the use of UDP as a transport layer protocol rather than the TCP/HTTP combination.

Also, **the smartphone (Google's Nexus One) exceeded expectations**—it is roughly as powerful as a circa 2000 desktop machine and provides a sophisticated software development platform.



UDP and TCP performance: The blue graph represents the inter-arrival times under high network load conditions for MJPEG frames when using the TCP transport strategy; the red graph represents those times using UDP. In general, the UDP strategy demonstrated more consistent arrival and reduced lag between frames.



Smartphone to smartphone performance: The blue area represents the percentage of time required to decrypt a message that encodes a video image on the smartphone; red represents the time to parse the SOAP/XML message, and green represents the time to create the bitmap for rendering on the phone's screen. The SOAP/XML parsing time dominates the other times, requiring more than 8 times the decryption time, and more than 5 times the bitmap creation time.

Next Steps

The experiments identified other engineering issues to consider in future work, including

- improving performance through support of *on demand* messaging
- implementing a reliability layer on top of UDP to address issues that arise when packets carrying text messages are lost
- splitting messages across packets to support higher resolution images (UDP packet size limit is 64K)
- evaluating limitations and incompatibilities of SOAP implementations for smartphones and Windows computers