Adapting Web Services for Limited Bandwidth Tactical Networks

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Outline

• Web Services
  – Push vs pull communication
  – Standardization efforts
• Optimizations
  – data representation
  – data communication
• Summary
Web Services and Network Based Defence

- Web Services is in widespread use on the Internet today.
- COTS products are readily available.
- Web Services is being considered as an enabling technology for NEC, and seem well suited.
- Web Services provides both synchronous and asynchronous communication.
"Push" vs "Pull" communication

**Push:**
- Push information to recipient.
- Asynchronous: No polling, which reduces communication overhead. Non-blocking.
- Example: Event service
- Good for wide-area distributed systems

**Pull:**
- Actively fetch information from server.
- Synchronous: Polling; communication overhead and potential blocking of the application.
- Example: Remote procedure call
An Event Service

- Asynchronous dissemination of information.
- Participants:
  - *publishers*, that submit information to the system, and
  - *subscribers*, that express their interest in specific types of information.
Web Services pub/sub standardization efforts

- The asynchronous nature of the publish/subscribe paradigm makes it a very important mode of communications in NBD.
- Two standardization efforts regarding publish/subscribe:
  - OASIS finished its Web Services Notification (WSN) standard late in 2006.
  - W3C has a draft version of a similar framework called Web Services Eventing (WS-Eventing).
  - WSN has most features.
WS-Notification

- Three parts to the WSN specification:
  - **WS-BaseNotification**
    - The WS-Eventing specification provides similar functionality to that of WS-BaseNotification, but they are not compatible with each other.
  - **WS-BrokeredNotification** defines the interface for notification intermediaries, i.e. notification brokers.
  - **WS-Topics** enables users to specify the types of events in which they are interested.
Web Services and Network Based Defence

- Pub/sub is well suited for use in a military context:
  - track updates,
  - building COP, and
  - creating situational awareness.

- Challenges when using web services over tactical communications links
Tactical networks

• Volatile medium
  – low bandwidth
  – high delay
  – unstable connections

• Challenges when using Web Services
  – Compression
  – Information representation and encoding
  – Optimizing transport (e.g. caching, multicast)
Information representation

• Work by Gerz et al\(^1\)
  – Message based communication
    • Referentially complete message, e.g., self-contained XML document.
    – Replication based communication (“push”).
    – Query based communication (“pull”).
• A combination may be most suited for Web Services
  – Adapting the message representation
  – Mainly status updates (“replication”)
    • Retrieving missing data using queries.
  – Standardization required for interoperability.

\(^1\)Gerz, M., Loaiza, F., and Chaum, E. “An Object-Oriented XML Schema for the MIP Joint Command, Control, and Consultation Information Exchange Data model”, CCRTS 2006
Optimizing transport

- Pub/Sub optimization by proxy
  - content filtering
    - deliver only relevant and necessary information
  - unicast/multicast gateway
    - utilize the underlying transmission medium
  - subscriptions on behalf of clients
    - reduce network traffic
    - increase scalability

- Request/Response optimization by proxy
  - caching of responses
    - reduce network traffic
    - increase scalability
Subscription by proxy

Server (S) <-> Proxy (P) <-> Clients

subscribe(P,S) <-> subscribe(A,S)
ack(P) <-> ack(A)
subscribe(B,S) <-> subscribe(P,S)
ack(B) <-> ack(P)
Notification via proxy, unicast

Server (S) → Proxy (P) → Clients

notify(P) → notify(A) → notify(B)

Clients

Server

Proxy
Notification via proxy, multicast

Server (S) \(\leftrightarrow\) Proxy (P) \(\leftrightarrow\) Clients

notify(P) \rightarrow\rightarrow\rightarrow\rightarrow\rightarrow multicast_notify(A,B)
Caching

- Server (S)
- Proxy (P)
- Clients

- Low bandwidth
- Medium bandwidth

- request(A, object.x)
- request(B, object.x)

- object.x
- object.x

- object.x
Other considerations

- COTS Web Services use HTTP over TCP as default
  - not suited to tactical networks
  - we are currently evaluating other means of transport
- What about security?
  - More information available to the proxy means more ways to optimize data flow. (Security on link layer.)
  - Little information available to the proxy, less ways to optimize data flow. (End-to-end application level security.)
Summary

• Web Services – well suited for implementing NEC, but
  – verbose - based on XML, so inefficient in tactical networks
• Means to adapt Web Services
  – compression
  – proxy servers
  – information representation optimization