THE STATE UNIVERSITY OF NEW JERSEY
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INFORMATION QUALITY:
RELIABILITY OF NCO INFORMATION PRODUCT DELIVERY SERVICES

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THEME

- NCO stands or falls on the quality of information delivered to the user
  - User develops accurate situational awareness
  - User makes good decisions
- Even information of the highest quality is useless if the user can't get at it
  - Information product delivery *services* must be *reliable*
- This research targets the information producer-distributor-user *system*

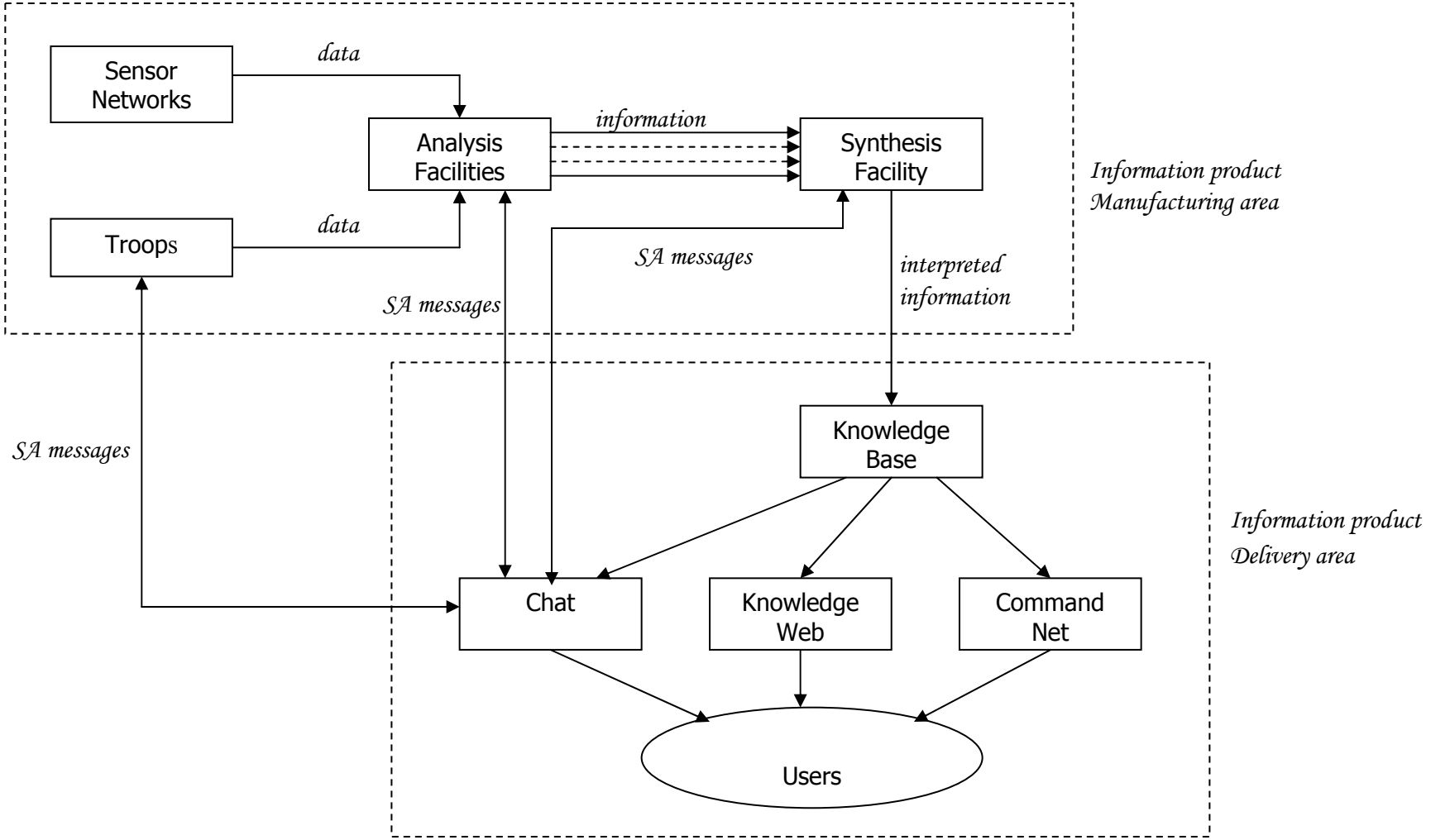
OVERVIEW

- Information product delivery services in NCO
  - Examples
  - General framework
- Information product delivery service reliability
  - Definitions
  - Figures of Merit and Metrics
  - Models
  - Examples
- Case study findings
- Discussion
- Conclusions and future work

NCO INFO PRODUCT DELIVERY SERVICES

- Examples
  - CTF50
    - + Knowledge Web (KWeb)
    - + Chat rooms
    - + CommandNet
  - Stryker Brigade
    - + SBCT Network
      - Satellite communications wide-area network (WAN),
      - TOC-to-TOC network (TOC = tactical operations center),
      - Tactical Internet
      - Command Net Radio Network (CNR), and
      - Global Broadcast System

NCO IP DEL'Y SVCS
GENERAL FRAMEWORK



NCO IP DELIVERY SERVICES RELIABILITY

- Each instance of an information product's being transferred to a user constitutes a *transaction* in the service
- Example: KWeb pull services
  - User requests a particular page (URL)
  - Server accepts request & sends page
  - User reads page
  - User finishes with that page

NCO IP DELIVERY SERVICES RELIABILITY

- KWeb, whatever else it may be, is a delivery service for pages stored on a remote server
- For these pages (information products) to be useful, the delivery service must be reliable

SERVICE RELIABILITY DEFINITIONS

- Service accessibility
  - Can start up a transaction in the service when desired
- Service continuity
  - Successfully-started transaction carries through to completion without interruption
  - All perceptual variables (*e. g.*, audio, video) have satisfactory quality throughout
- Service release

SERVICE RELIABILITY
FIGURES OF MERIT

- $\alpha(t; \underline{v}) = P\{$transaction setup attempt at time t is successful when prevailing conditions are $\underline{v}\}$
- $\gamma(t, h; \underline{v}) = P\{$a transaction successfully set up at time t and lasting for duration h is successfully completed at time $t + h$ when prevailing conditions are $\underline{v}\}$
- Figures of merit are developed from models of the IPDI and its operations

SERVICE RELIABILITY METRICS

- Metric is a statistic that estimates a figure of merit

- $$\hat{\alpha} = \frac{\#\ \text{of successful transaction setups}}{\text{total \# of transaction setup attempts}}$$

- $$\hat{\gamma} = \frac{\#\ \text{of successfully completed transactions}}{\text{total \# of successful transaction setups}}$$

SERVICE RELIABILITY MODELS

- Queueing networks
  - Packet delay distribution
- Stochastic flow networks
  - IPDI failures in OSI 7-layer model context
    - + Accidental
    - + Deliberate
  - Information deterioration in transit
- In all cases, connect to service accessibility and continuity FOMs via the relevant failure modes and failure mechanisms

SERVICE RELIABILITY EXAMPLES

- Wireless telephony
  - Failure mode: dropped call
  - Failure mechanisms: weak signal, base station failure, MSO failure,…
- Package delivery
  - Failure mode: late delivery
  - Failure mechanism: numerous!
- Electric utility
  - Failure mode: incorrect bill
  - Failure mechanism: numerous!

SERVICE RELIABILITY MODELING FRAMEWORK

$$\mathrm{FOM}(t,h;\underline{v}) = P\left(\bigcup_{i=1}^{m}\{\text{Failure mode } i\}\right) =$$

$$= P\left(\bigcup_{i=1}^{m}\left\{\bigcup_{j=1}^{n_i}\text{Failure mechanism } j \text{ for failure mode } i\right\}\right)$$

SERVICE RELIABILITY REQUIREMENTS

- Set requirements for desired service reliability characteristics
- Use the framework (slide 13) to see how to arrange the IPDI reliability requirements so that the desired service reliability requirements are met

KWEB ANALYSIS
SERVICE ACCESSIBILITY

BREAKDOWN FAILURES		PERFORMANCE FAILURES	
MODES	**MECHANISMS**	**MODES**	**MECHANISMS**
Browser does not open when requested	▪ PC compromised o Worm/virus	Excessive delay in opening browser	▪ CPU overloaded o Legitimate activity o Virus/worm
No response to user request for page	▪ Server down ▪ Request misdirected o Deliberate ☞ Opposing force wiretap o Accidental ☞ Routing table errors	Excessive delay in responding to user request for page (starting page load)	▪ IPDI congestion o Excess offered load o IPDI element failures o IPDI compromised ☞ Physical damage ☞ DOS attack ▪ Server overloaded o Excess traffic o Server subsystem failures o Server compromised

KWEB ANALYSIS SERVICE CONTINUITY

BREAKDOWN FAILURES		PERFORMANCE FAILURES	
MODES	**MECHANISMS**	**MODES**	**MECHANISMS**
Page load permanently stalled	▪ Packet loss and TCP failure o Incoming ▪ IPDI access failure	Excessive delay in completing page load	▪ IPDI congestion o Excess offered load o IPDI element failures o IPDI compromised ☞ Physical damage ☞ DOS attack ▪ Server overloaded o Excess traffic o Server subsystem failures o Server compromised
Subsequent page request refused/failed	▪ IPDI access failure ▪ Packet loss and TCP failure o Incoming o Outgoing	Incorrect page served to user	▪ Request corrupted in transit ▪ Server database corrupted ▪ Requesting page spoofed
		Audio and/or video garbled/unintelligible	▪ Packet loss ▪ Excessive packet latency

GBS ANALYSIS
SERVICE ACCESSIBILITY

- Global Broadcast System is a push service
  - Transaction begins when user turns attention to the interface
- Service accessibility is equal to the probability that the GBS is operating properly at the desired time
  - As a system
  - Receiving signals and displaying them
    - + Near zero latency

GBS ANALYSIS
SERVICE CONTINUITY

BREAKDOWN FAILURES		PERFORMANCE FAILURES	
MODES	**MECHANISMS**	**MODES**	**MECHANISMS**
Streaming audio or video stops, does not restart	▪ Loss of entire satellite ▪ Loss of dedicated transponder ▪ Loss of downlink ▪ Interface failure ▪ Broadcast origination failure	Streaming audio/video distorted/garbled	▪ Broadcast origination failure ▪ Interface failure ▪ Packet bearer bit errors ▪ IPDI congestion ▪ Excessive packet loss and/or delay
Static video disappears	▪ Remote refresh failure ▪ Interface failure	Gaps in streaming audio/video	▪ Intermittent satellite failure ▪ Intermittent dedicated transponder failure ▪ Intermittent downlink failure ▪ Intermittent interface failure ▪ Severe packet loss and/or delay

DISCUSSION

- Information assurance studies concern operation of the IPDI
  - But without understanding the effect of IPDI anomalies on the user, we are stuck with "less [bad stuff] is better"
- Explicit consideration of user needs enables setting requirements for IPDI behavior on a rational basis

CONCLUSIONS

- Reliability of the information product delivery service bears on key information parameters
  - Quality
  - Reliability
  - Risk to Use
- We have begun to understand how this works in NCO
- Much remains to be done

FUTURE WORK

- Complete a service reliability analysis in detail for a prospective NCO information product delivery service to show how early attention to service reliability concerns will positively influence the service architecture.
- Incorporate the effects of deliberate disruptive actions (e. g., opposing force action and/or software attacks such as denial-of-service attacks, worms, and the like) into service reliability studies.

FUTURE WORK

- Further enhance the application of service reliability theory to NCO by developing IPDI reliability models for failures at the transport, network, protocol, session, and application layers as well as the physical layer.
- Develop a model for the deterioration of information as it passes through a connectionless network of noisy channels.