Advances and Challenges for Decentralized Command and Control Systems Based on Computer Games and Virtual World Technologies

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Overview

- What is *Decentralized Command and Control (DC2)*?
- Computer games and virtual worlds for DC2
- Applications for DC2
- Scaling DC2 systems: capability versus cost
- DC2 challenges and opportunities for Cyber-security
- Lessons learned

- W. Scacchi, C. Brown, K. Nies (2011). *Investigating the Use of Computer Games and Virtual Worlds for Decentralized Command and Control*, Final Report for the Center for the Edge, Naval Postgraduate School, October 2011. http://www.ics.uci.edu/~wscacchi/ProjectReports/NPS-Reports/DECENT.pdf

Conventional C2 facility: mission management

Conventional C2 facility: *F1* race control

Conventional C2 facility: urban management

What is *Decentralized Command and Control (DC2)*?

- DC2 systems are C2 systems that can be:
  - -- logically centralized and physically dispersed
  - -- operated as virtual enterprises
  - -- used at “edge” of an multi-site organization
  - -- engage agents (avatars) and human actors
  - -- engage actors in different locations that are virtually collocated in a DC2 virtual world
  - -- “cloud” friendly

What can we do/study in a DC2?

-- Viable group presentation, communication, and social interaction

-- Prototyping and review of virtual objects, composite systems, etc.

-- Training, education, rehearsal, learning

-- New commercial product demonstration

-- Identity role-playing, team building, and other social processes

-- Multi-media storytelling and machinima production

-- Avatar control and choreography

-- Mirrored worlds and memorialization

-- Game development and modding

-- Semi-automated socio-technical process discovery

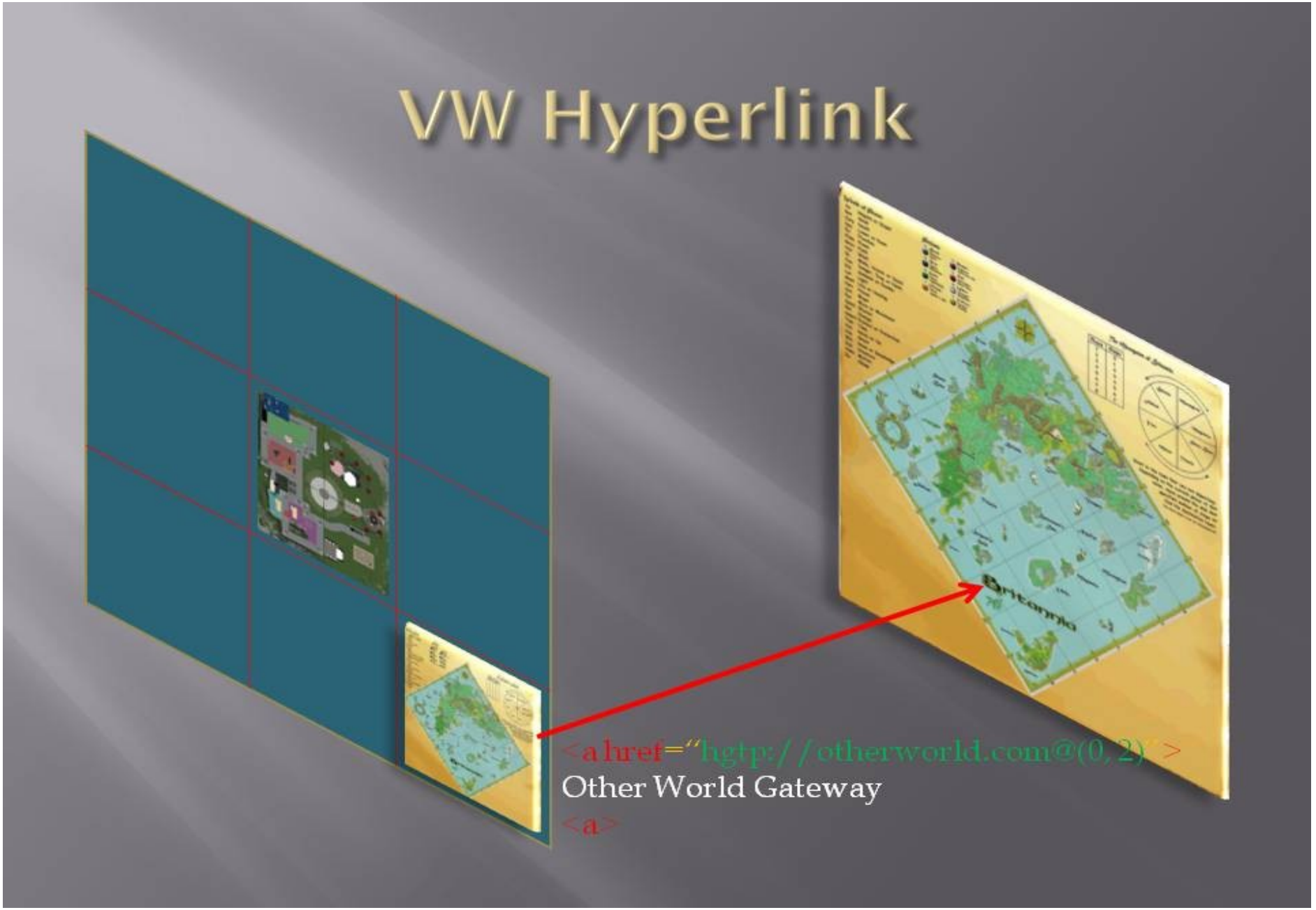
-- Modeling, visualizing, analyzing, and developing complex security regimes accommodating heterogeneous security policies

-- Enabling human behavior transformation (health care)

Virtualized C2 facility

Virtualized DC2 actors/avatars: where are their users located?

DC2 worlds can be linked into interoperable *hypergrids*



C. Lopes, (2011). Hypergrid: Architecture and Protocol for Virtual World Interoperability, *IEEE Internet Computing*, 15(5), 22-29, Sept-Oct 2011.

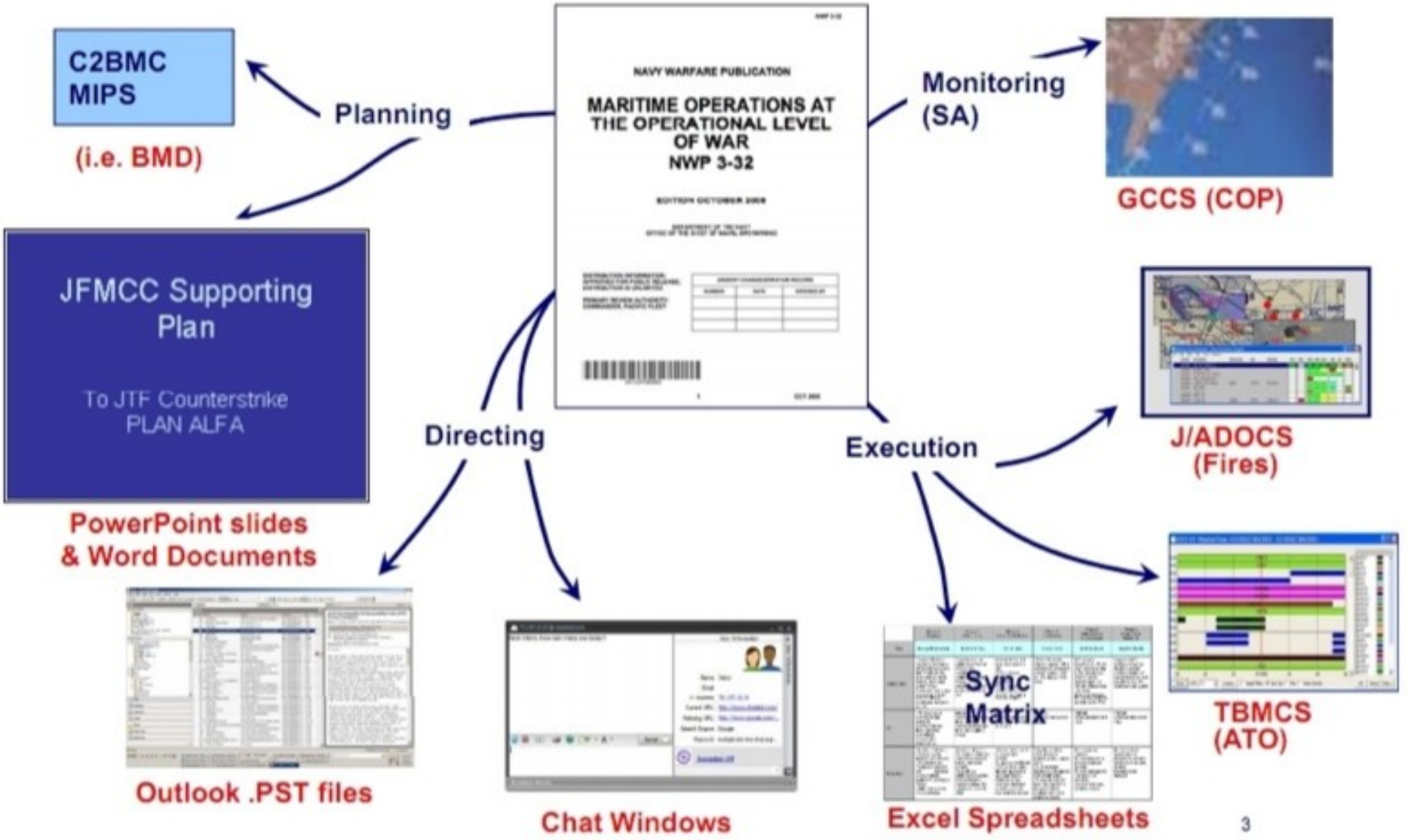
DC2 worlds can be linked into *hypergrids* across heterogeneous platforms

Military Open Simulator Enterprise Strategy: http://fvwc.army.mil/moses/

New DC2 platforms: personal, mobile, built into other devices/platforms

DC2 diverse clients (multi-version implementations) accessing common world

DC2 worlds should embed heterogeneous software system applications within extensible *open architectures*



C2RPC (2010). Command and Control Rapid Deployment Continuum Overview, http://www.afcea-sd.org/wp-content/uploads/2010/12/YoungAFCEA_C2RPC.pdf

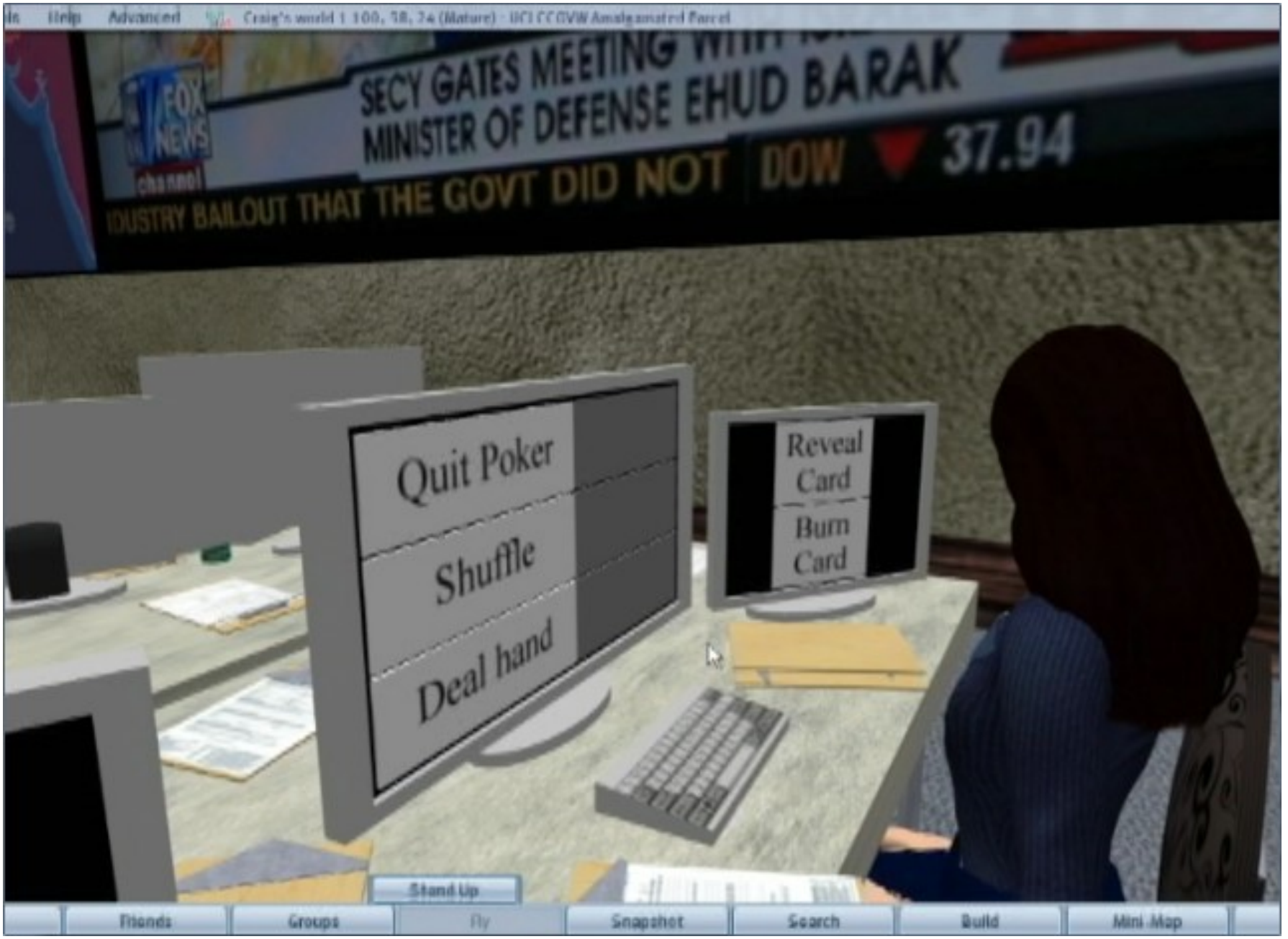
Computer games and virtual worlds for DC2

- Can we develop new concepts for traditional C2 using a game-based DC2?
  - Why?
    - Workforce development and performance evaluation (e.g., who does it best)
    - System design trade-off analysis, etc.
  - What kinds of games might be valuable to consider?
    - Role-playing game (RPG), real-time strategy (RTS), massively multiplayer online game (MMOG), city/enterprise simulations, card games (???)

EVE Online: MMOG for resource management in space combat

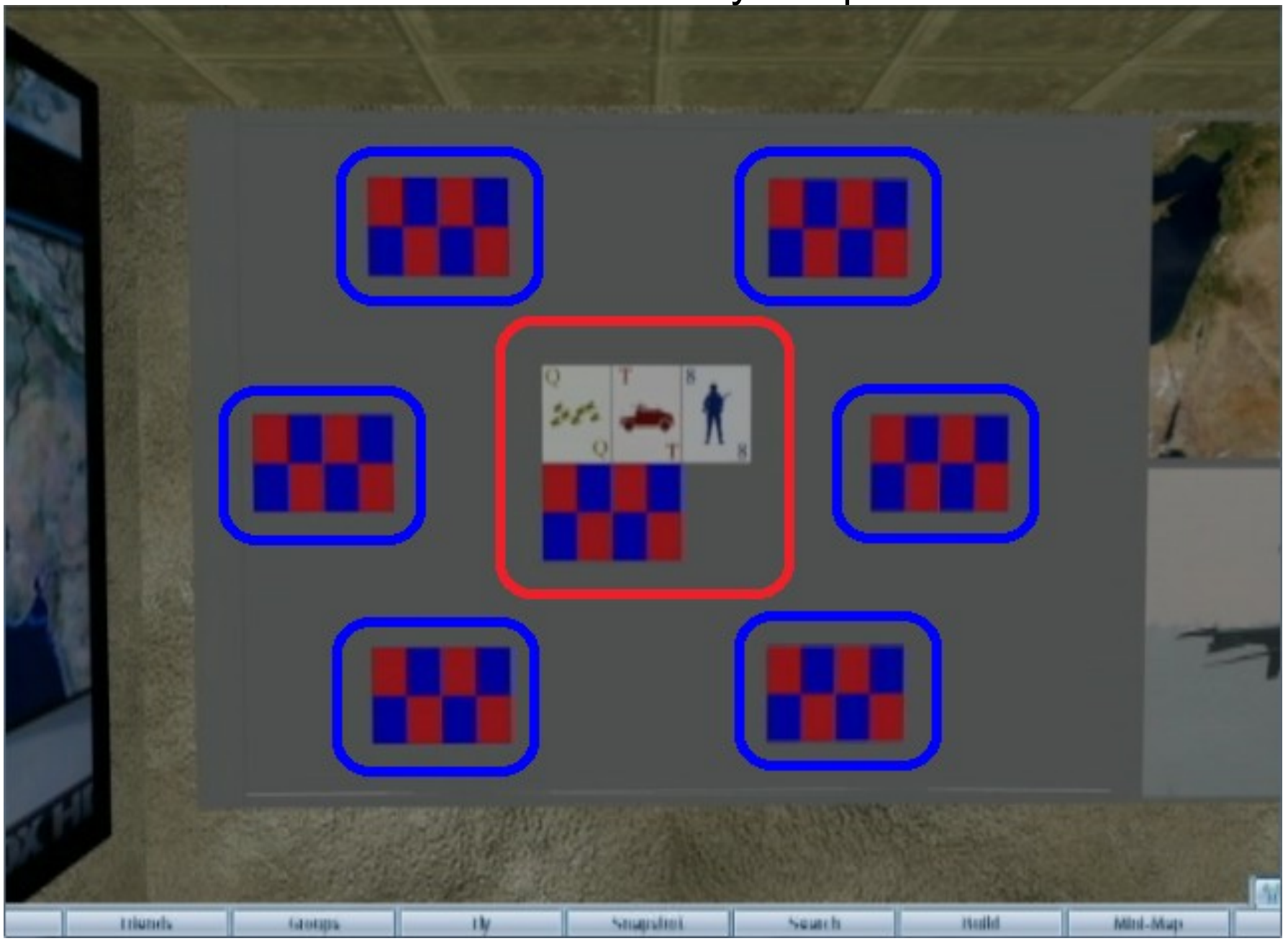
DC2 facility for mission management game play studies

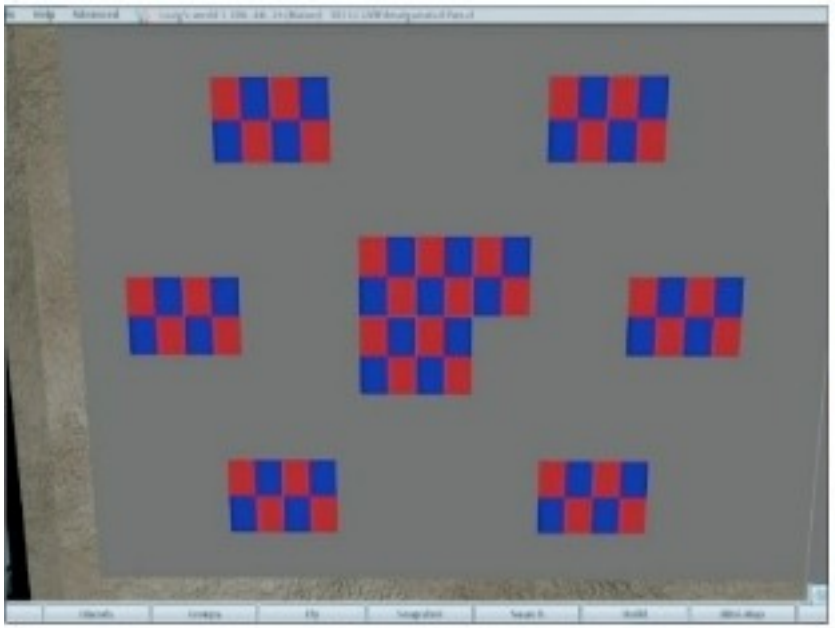
C2 mission management as *Texas Hold'em* Poker



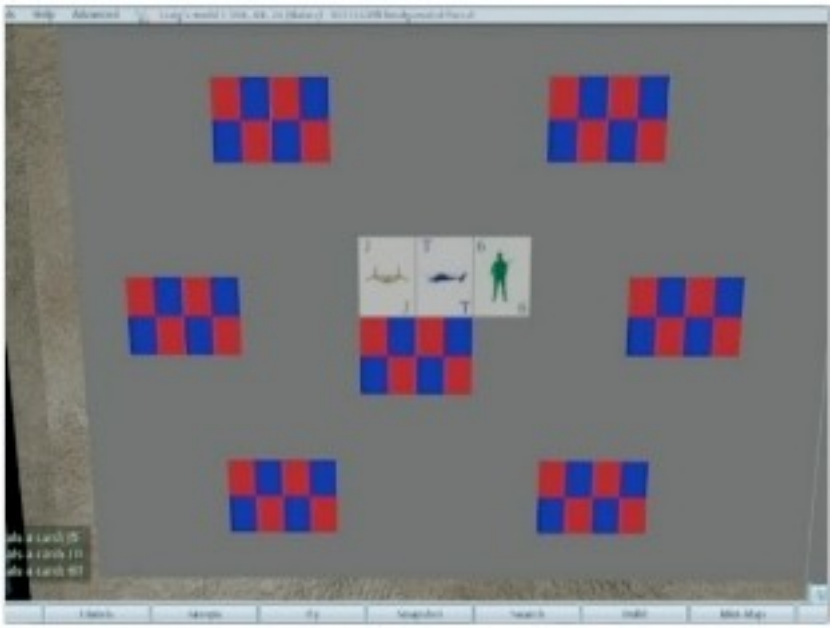
C2 mission management: incremental resource allocation with shifting uncertainty and outcomes

C2 mission management: situation awareness with uncertain actions and assets by competitors

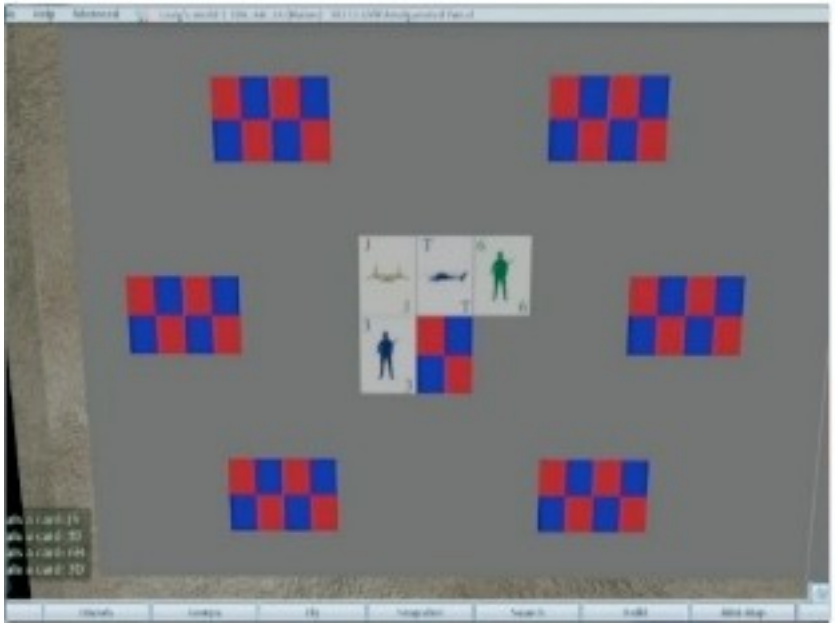


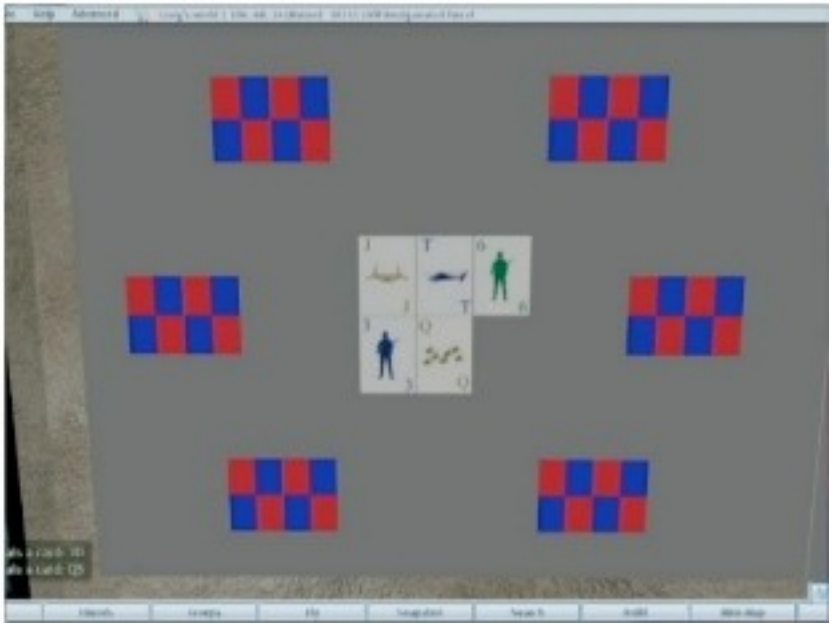


Pre-flop



Flop





Brute force

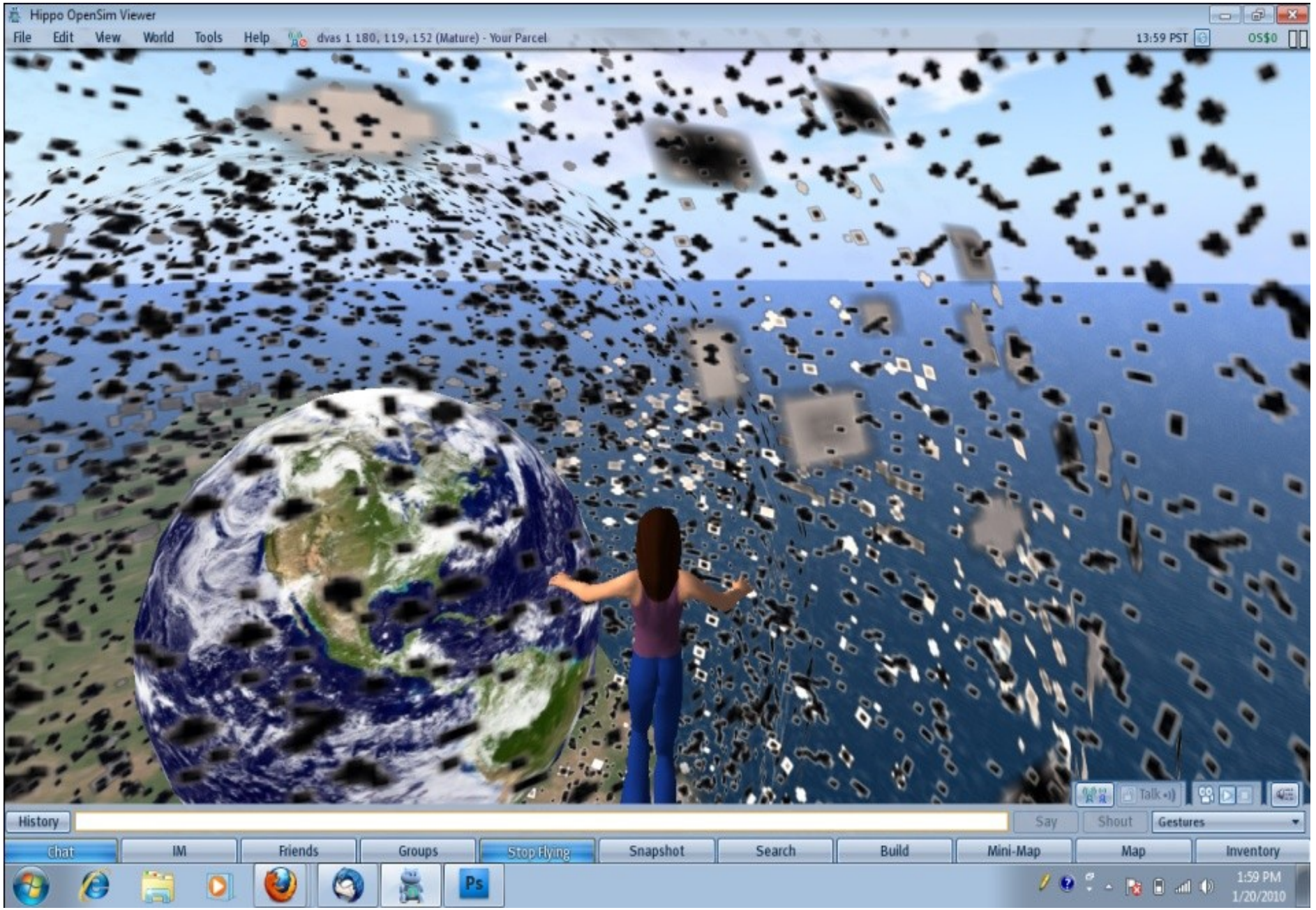
The enemy knew we were coming, and prepared for our best. Pure numbers will win today.

Cards with values of Jack and higher cannot be played. Aces can be played with value 1.

Applications for DC2

- DC2 can be prototyped using open source software components
  - Lowers acquisition cost; allow for experimentation in new system designs; disposable systems
  - New application areas can be explored, prototyped, evaluated by dispersed users

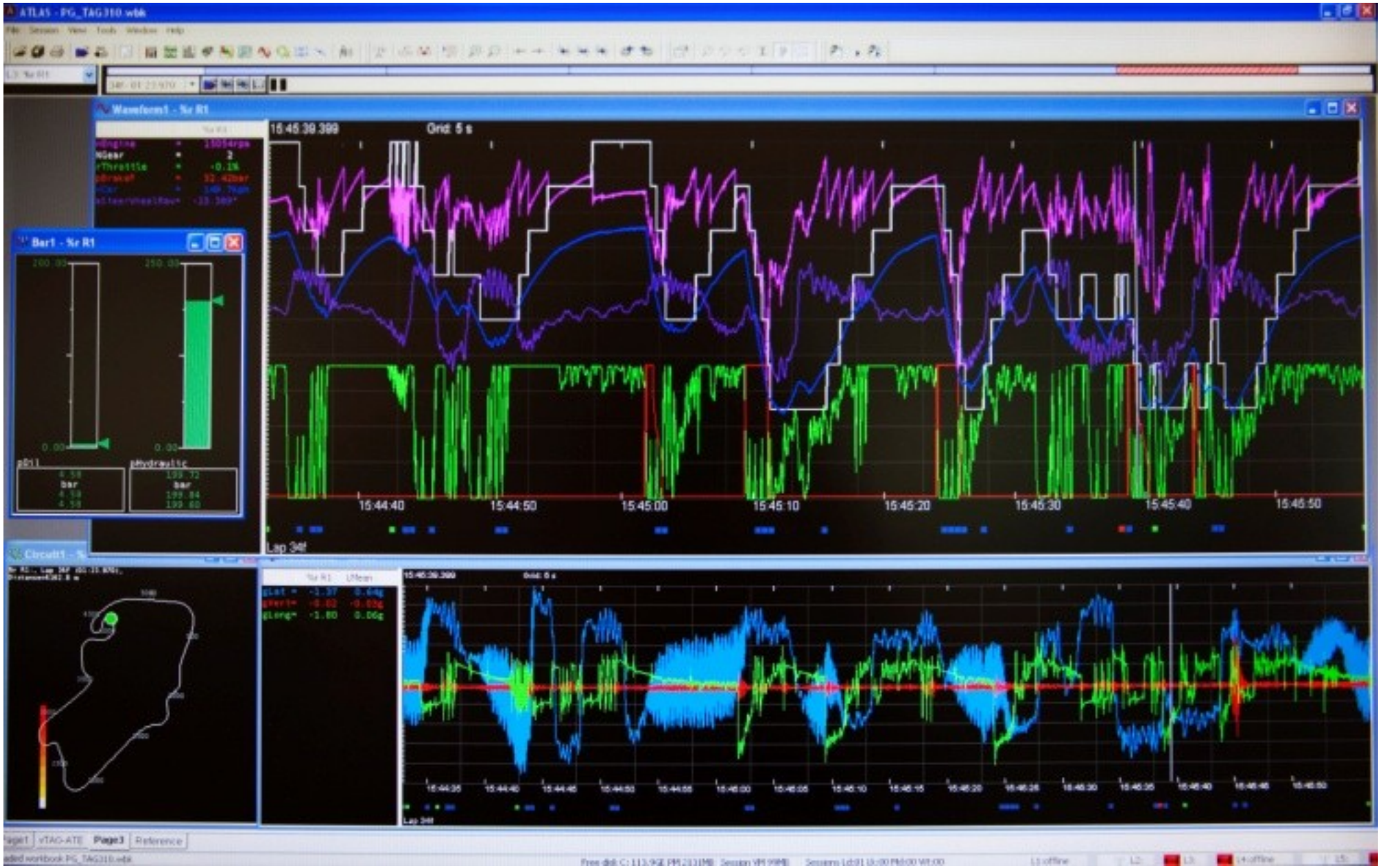
Applications for DC2: space debris tracking, fly-through, clean-up, mirrored objects trajectories, etc.



Back to the *F1* race

F1 race team DC2 deployments: trackside, race control trailer, global remote factory

F1 race control: multiple sensors, real-time event telemetry streams, real-time information fusion coordinated across team sites



Drugmaker GSK inspired by McLaren F1 mission control

Thu, Sep 15 2011

By Kate Kelland

LONDON, Sept 15 (Reuters) - Can fast cars help you sell more drugs? Executives at GlaxoSmithKline think so.

The British drugmaker is teaming up with the Formula One motor racing engineers McLaren in the hope it can pick up new tips on innovative business operations and high-tech research.

The partnership, which will run initially until 2016, means the Formula One experts McLaren will share its capabilities in engineering, technology, analytics and strategy modelling to help boost GSK's global business performance, the firms said in a joint statement.

The partnership will initially focus on GSK's manufacturing, research and development (R&D) and consumer healthcare departments.

GSK's consumer healthcare business, which markets brands such as Lucozade, Panadol and Sensodyne, will work with McLaren's Formula 1 "Mission Control" -- the unit which analyses the team's performance and directs decision making to drivers during a Grand Prix -- to construct something similar at GSK's London Headquarters.

The drugmaker said this should enable faster responses to competitor activity and customer needs and improve decision making on inventory management, pricing, and retailer

Scaling DC2 systems: capability versus cost

Application for DC2: modeling and simulating C2 capabilities and system integration

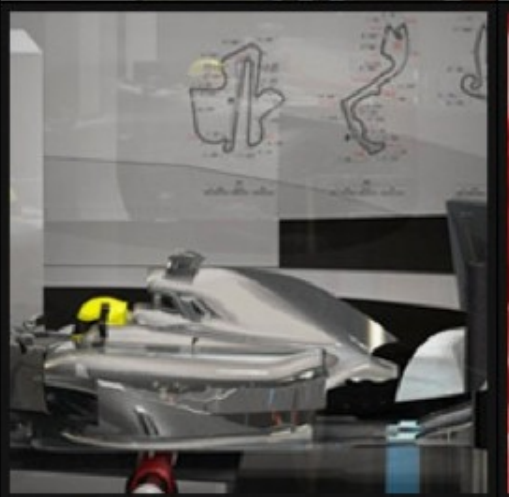
MODELLING AND SIMULATION

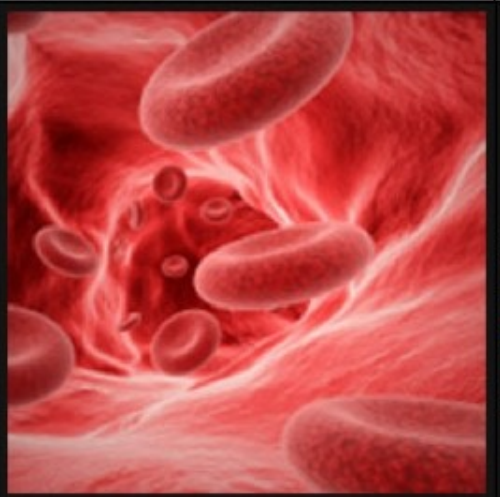
McLaren has the best simulator in motorsport and the only one that was built from the outset for design as well as driver training purposes.

This approach delivers outstanding results for driver and team training together with high fidelity predictions of race performance to inform the design process. Modelling and simulation are key to our racing success and have been applied successfully for other organisations to realise operational excellence. If you want to know more, Talk to us.

Modelling used for race strategy and analysis can be applied for traffic management on roads, rail or in the air.

Modelling and simulation offer unique opportunities for immersive training and practice for complex surgical procedures in a risk-free environment.





Scaled game-based VW simulator interfaces:
Can we do the same for DC2 applications?

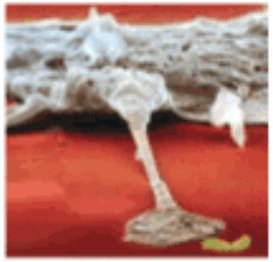
What can we learn about Cyber-security from a DC2 perspective?

- Quick, limited review of DARPA and ONR programs in cyber-security

  -- Focusing on software systems

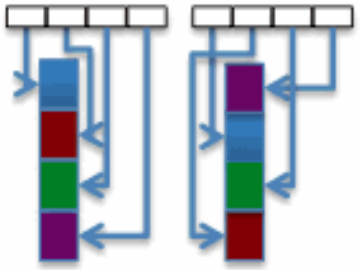
CRASH Applies Biological Principles to Computation

Innate Immunity:
New hardware & operating system architectures
that eliminate all common technical vulnerabilities



Adaptive Immunity
Middleware that:

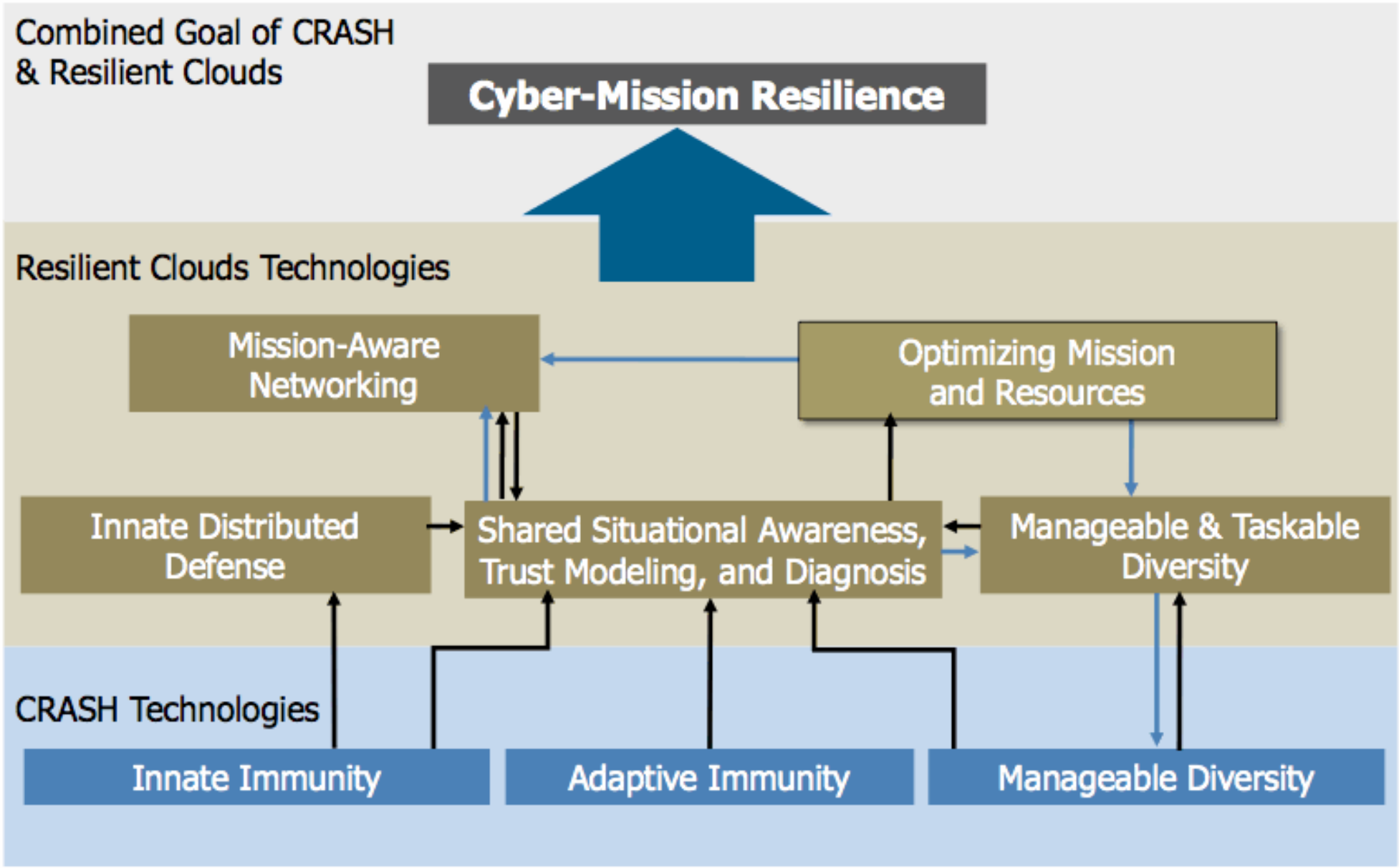
- Diagnoses root causes of vulnerabilities and builds situational assessment
- Quickly adapts & reconfigures
- Learns from previous attacks and gets better at self-protection



Population Diversity
Computational techniques that:

- Increase entropy in time and space
- Make every system unique
- Raise work factor of attacker for each system

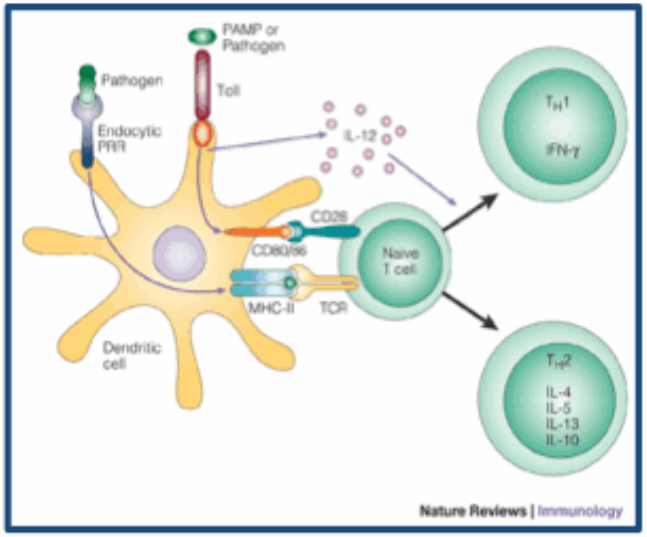
Resilient Clouds Technology Areas



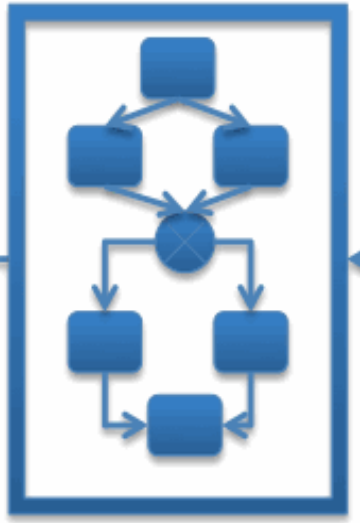
For more info see: http://tinyurl.com/68w9wpf

→ Information flow
→ Control flow

Adaptive Immunity

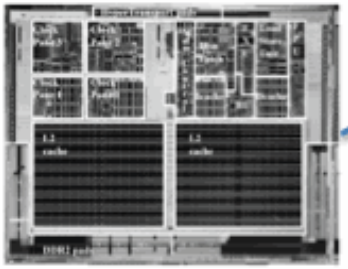


System Model



4. System model is adapted with new attack-specific detector

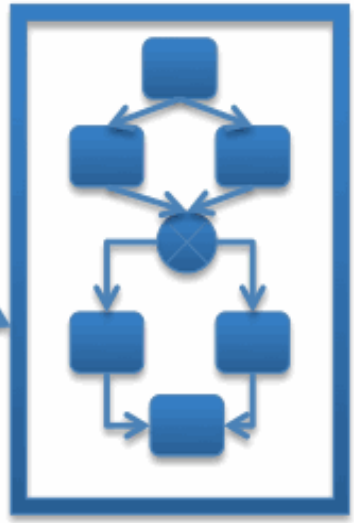
3. System model is used to perform diagnosis (e.g. localization and characterization)



1. Hardware analog of innate immune system detects anomaly

2. Software system analog of adaptive immune system is signaled

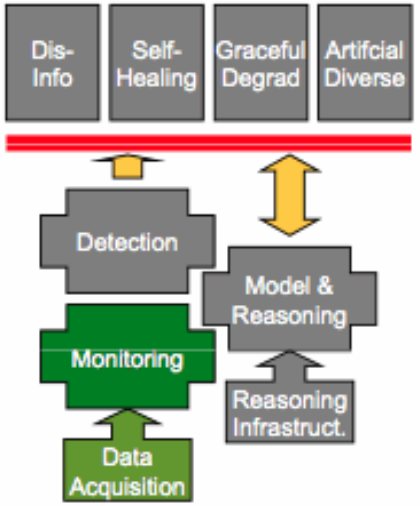
5. Adaptive immune system synthesizes plan to get around problem and patch to remove specific vulnerability



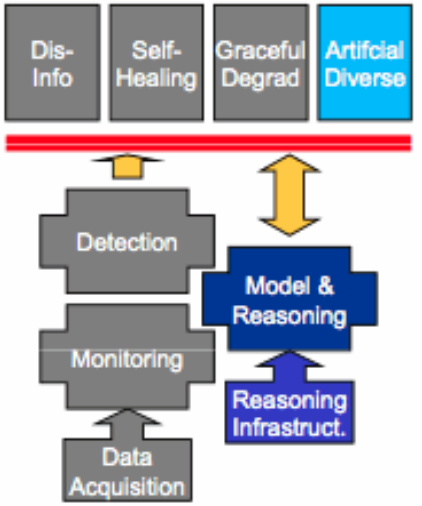
ONR's Proposed Approaches to Cyber Security Challenges

- **Addressing Asymmetric (static, large footprint):**
  - Artificial diversity → mostly host, potentially network
  - Dynamic re-configuration → host and network
  - Dis-information → host
- **Addressing Vulnerable Systems & Inherently Insecure COTS:**
  - Security aware software development environment
  - Active detection, active defense
  - Fight through damage: failure recovery, damage control, graceful degradation
  - New sw & hw architecture developed with security "baked-in"
    - → GOTS (new architecture or modification of COTS)
    - → Can DoD influence COTS development ?
    - → Should any IA/IO features be strategically kept out of COTS ?

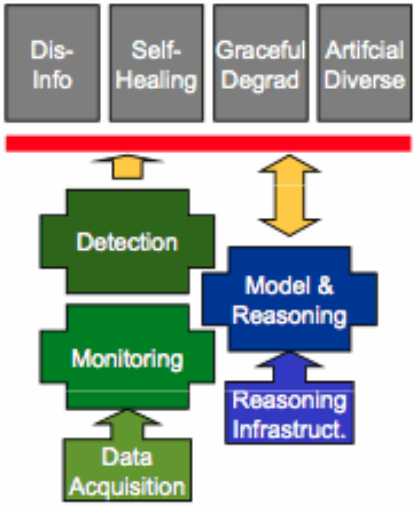
Robust Autonomic Computing System
Research Topics



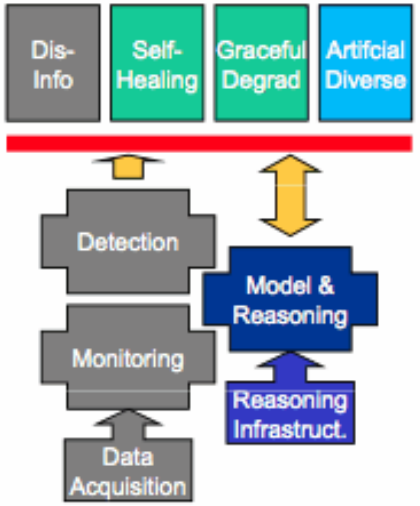
Data Acquisition & Monitoring



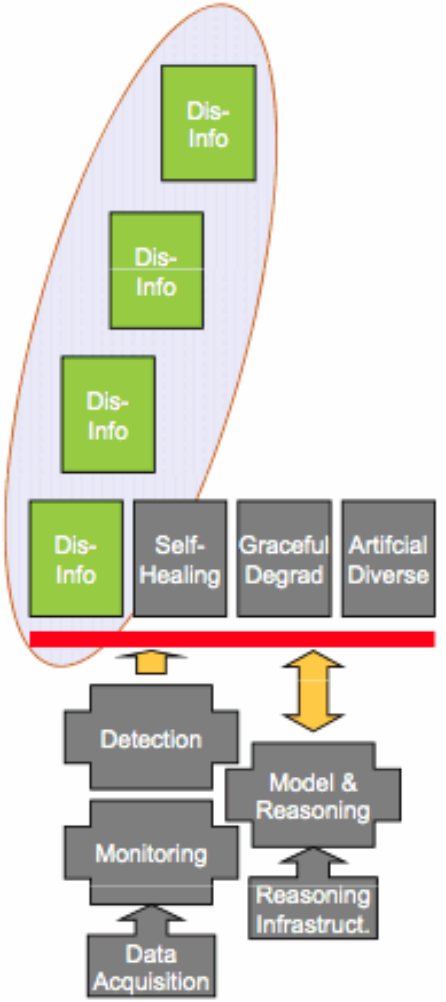
Syst. Reasoning & Artif. Diversity



Self-Aware



System Reasoning & Resiliency

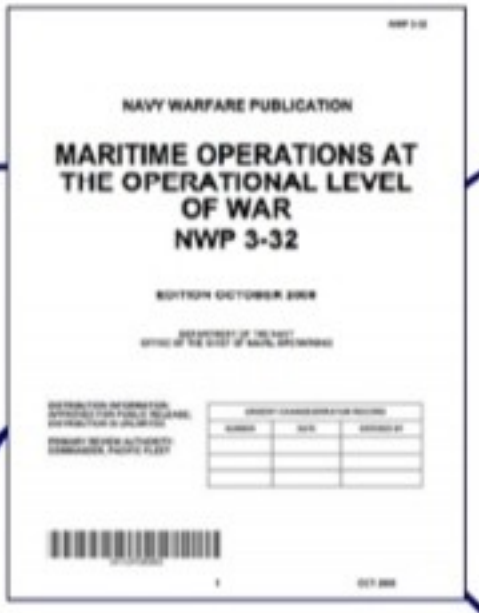


Collaborative Disinformation

C2BMC
MIPS

(i.e. BMD)

Planning



Monitoring (SA)

GCCS (COP)

JFMCC Supporting Plan

To JTF Counterstrike
PLAN ALFA

PowerPoint slides & Word Documents

Directing

Execution

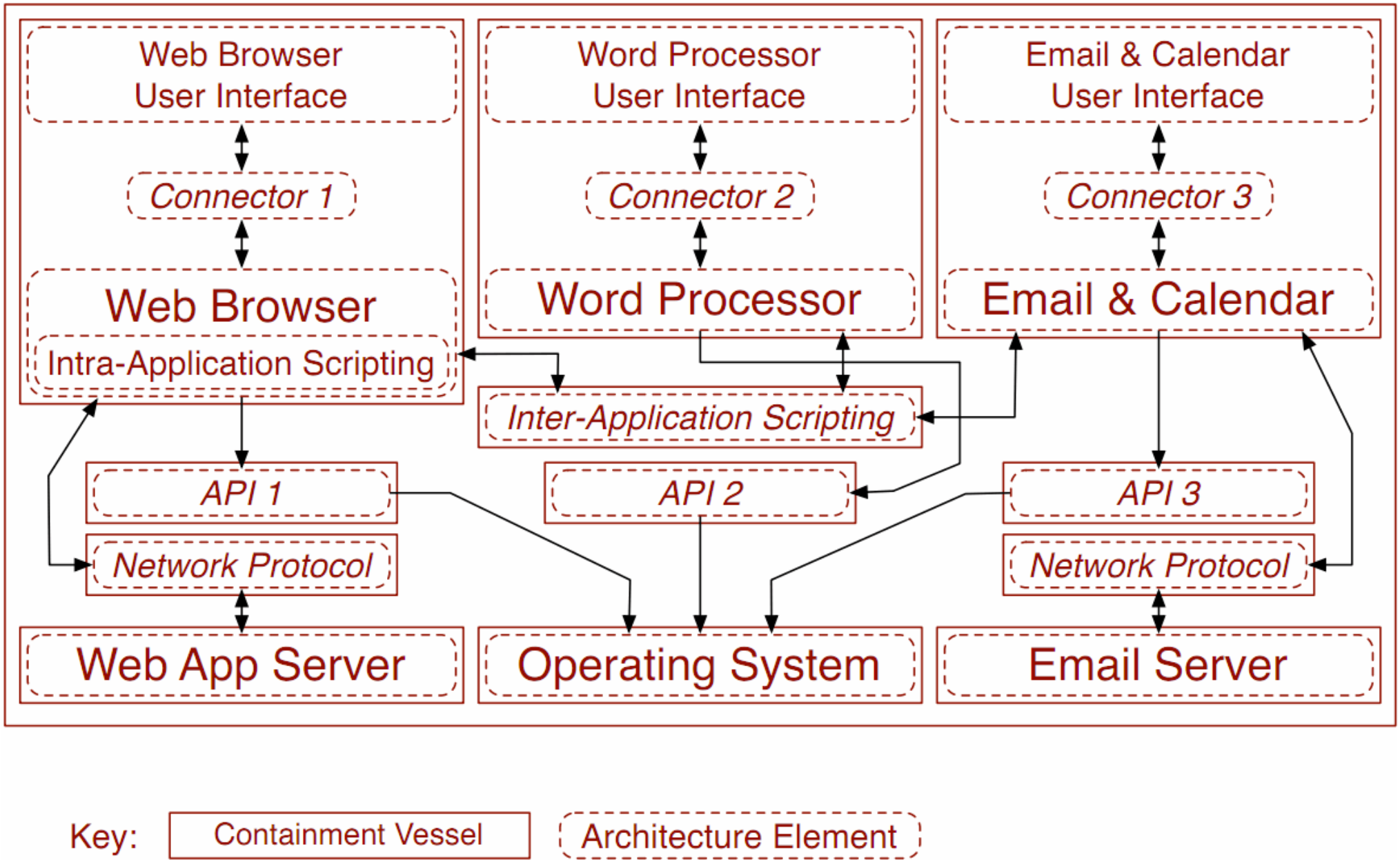
J/ADOCS (Fires)

Outlook .PST files

Chat Windows

Excel Spreadsheets

TBMCS (ATO)


Web Browser
User Interface
Connector 1
Web Browser
Intra-Application Scripting
Word Processor
User Interface
Connector 2
Word Processor
Email & Calendar
User Interface
Connector 3
Email & Calendar
Inter-Application Scripting
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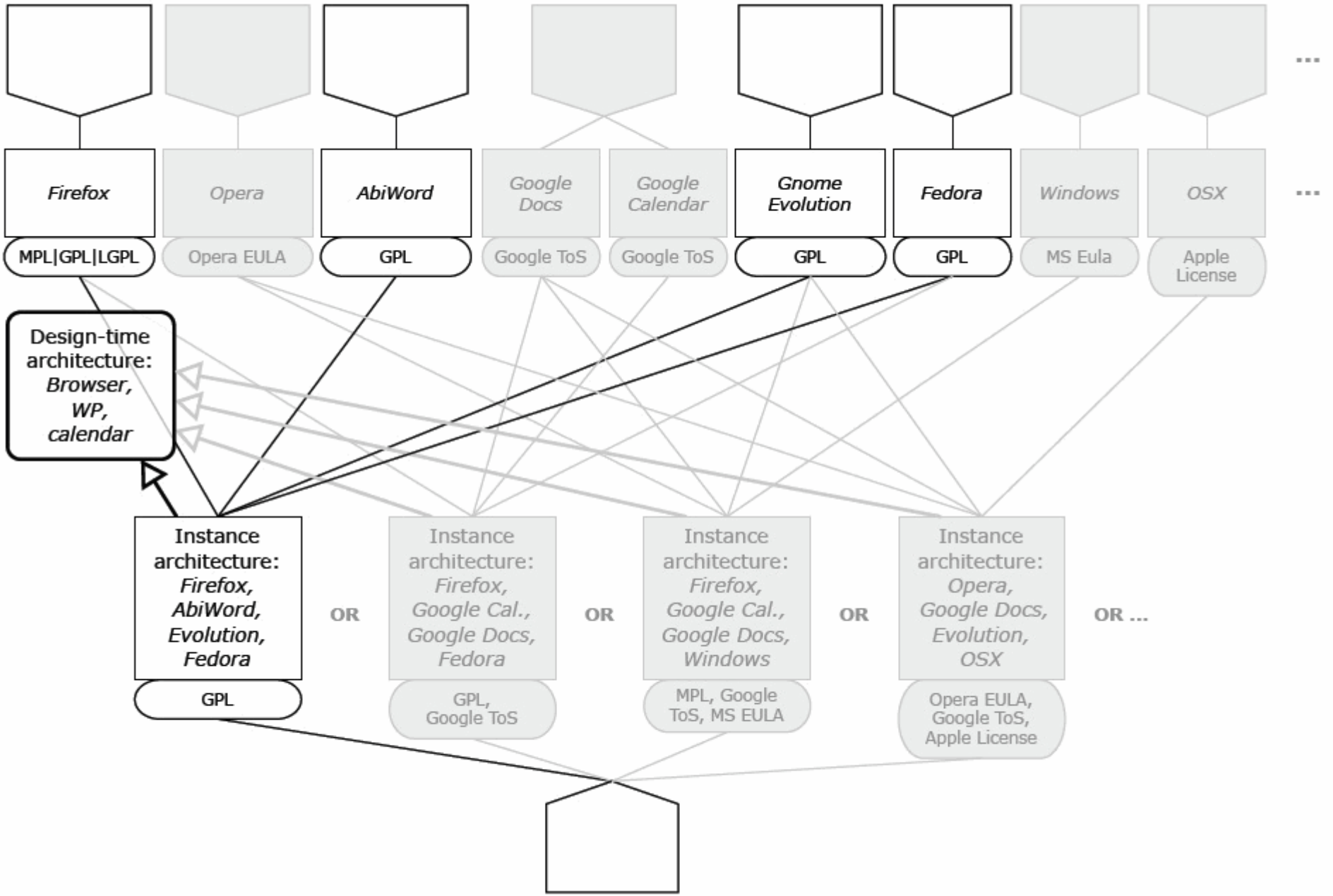
API 2
API 3
Network Protocol
Network Protocol
Web App Server
Operating System
Email Server
Key:
Containment Vessel
Architecture Element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AbiWord
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Google ToS
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GPL
MS Eula
Apple License
Design-time architecture: Browser, WP, calendar
Instance architecture: Firefox, AbiWord, Evolution, Fedora
GPL
OR
Instance architecture: Firefox, Google Cal., Google Docs, Fedora
GPL, Google ToS
OR
Instance architecture: Firefox, Google Cal., Google Docs, Windows
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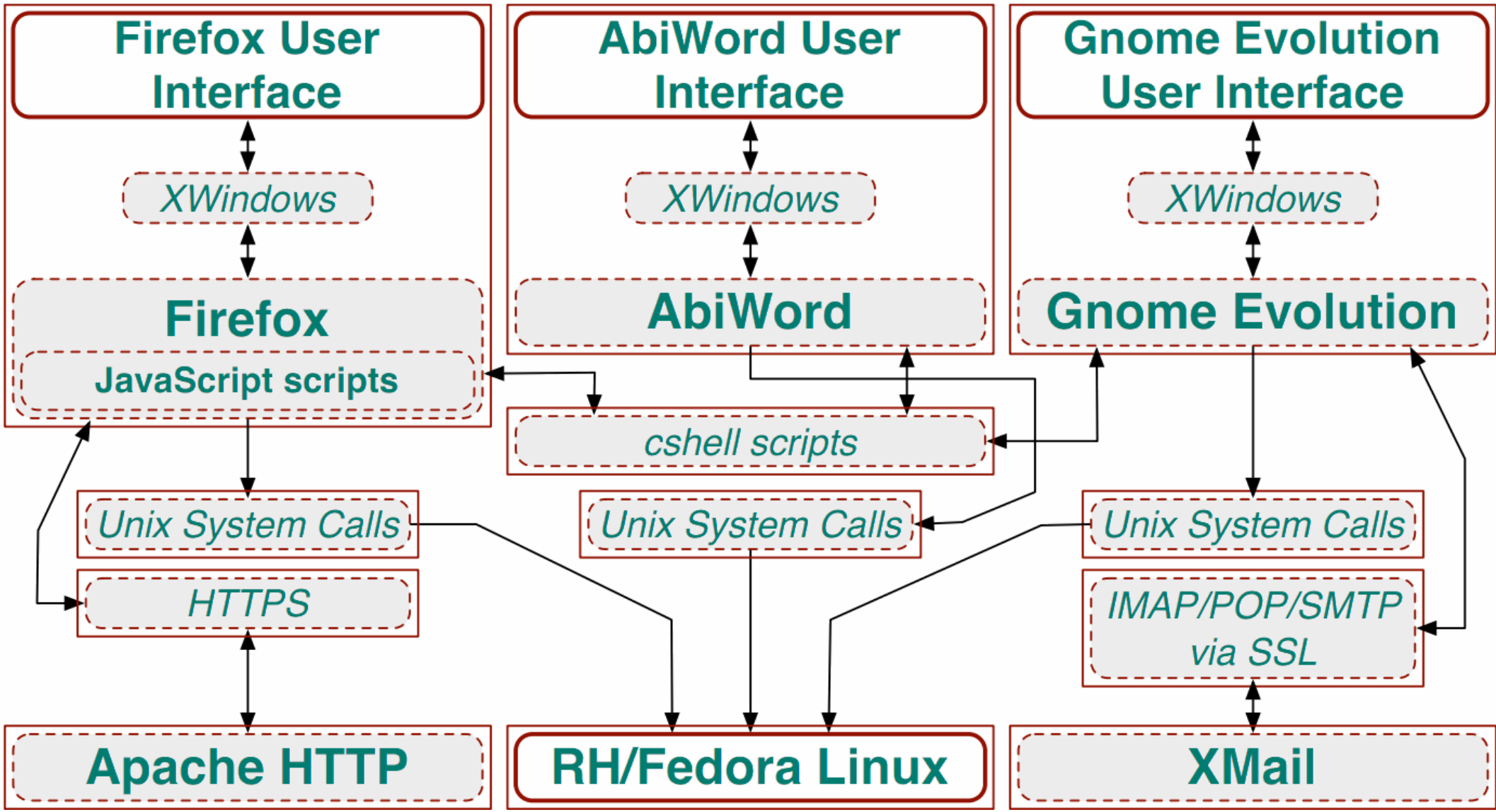
Firefox User Interface
AbiWord User Interface
Gnome Evolution User Interface
XWindows
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Firefox
JavaScript scripts
AbiWord
Gnome Evolution
cshell scripts
Unix System Calls
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Unix System Calls
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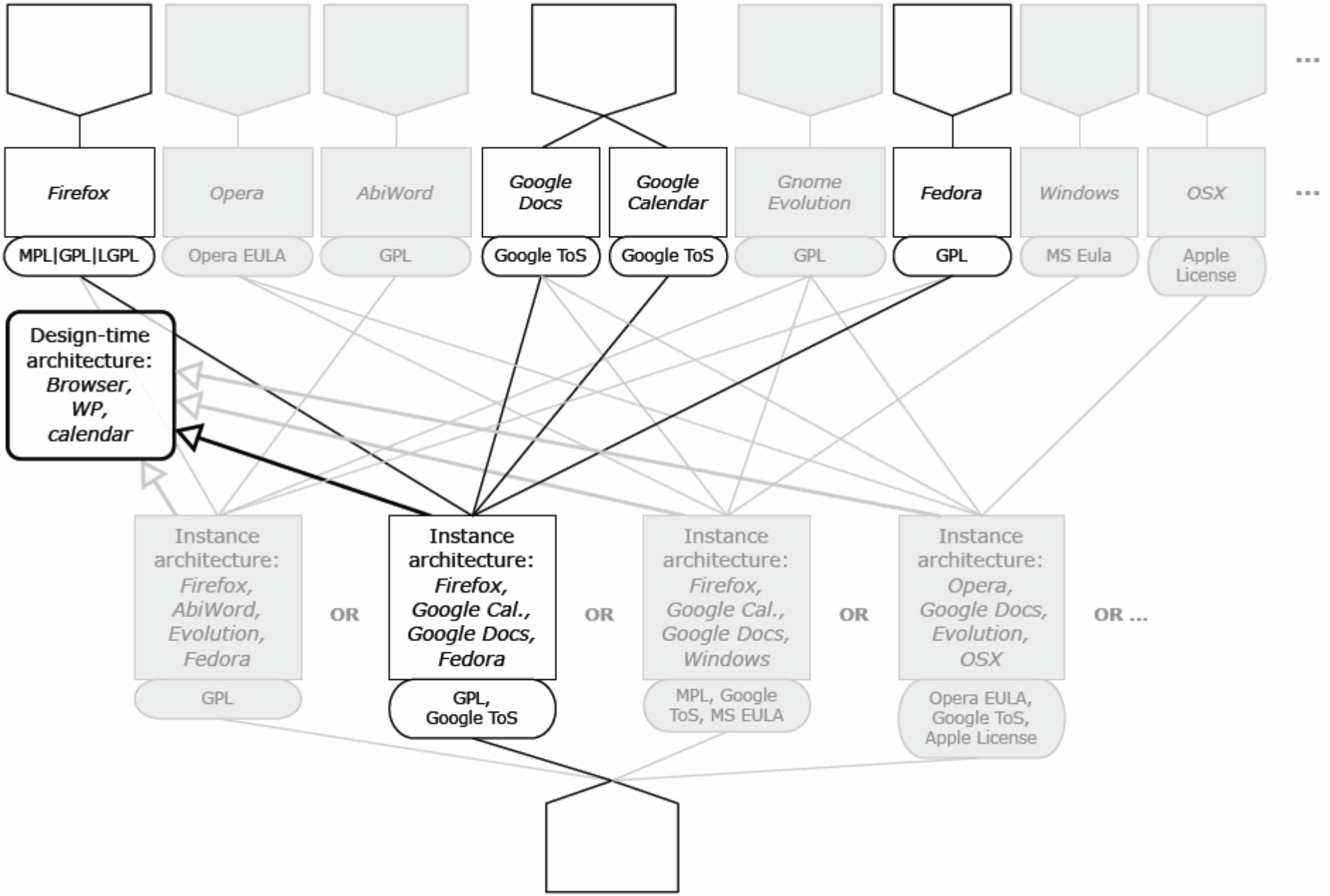
Apache HTTP
RH/Fedora Linux
XMail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Opera EULA
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Google ToS
Google ToS
GPL
GPL
MS Eula
Apple License
Design-time architecture: Browser, WP, calendar
Instance architecture: Firefox, AbiWord, Evolution, Fedora
GPL
OR
Instance architecture: Firefox, Google Cal., Google Docs, Fedora
GPL, Google ToS
OR
Instance architecture: Firefox, Google Cal., Google Docs, Windows
MPL, Google ToS, MS EULA
OR
Instance architecture: Opera, Google Docs, Evolution, OSX
Opera EULA, Google ToS, Apple License
OR ...

DC2 insights on cyber-security initiatives

- Biologically inspired approaches
  - "creature adaptation," but not "evolving ecosystems" of multi-version, multi-generation software system architectures (for prey and predators)
- Possible to design, build, deploy evolving ecosystem models of secure software systems
  - No compelling models or simulations of C2/DC2 for cyber-security or cyber-warfare
  - No visual/VW models of security processes (defense or offense), nor secured C2/DC2 systems

Lessons to learn

- What is *Decentralized Command and Control (DC2)*?
  - Something to master; invest in now
- Computer games and virtual worlds for DC2
  - Enable new ways and means for experimenting with new DC2 concepts, techniques, workforce
- Applications for DC2
  - Potential for DC2 product line architectures and (domain-specific) application generators
- Scaling DC2 systems: capability versus cost
  - Finding the sweet-spot in scalable capability/cost.
- DC2 challenges and opportunities for Cyber-security
  - Great R&D opportunities; visualize security

Acknowledgements

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- UCI Video Game Developers Club (students)
- *No review, approval, or endorsement implied*.