Simulation-based Command and Control Applications in a Service-Oriented Environment

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Outline

- Background
- C2 Concepts
- Operational Picture and Situational Assessment
- C2 Operational Domains
- M&S use in C2
- Service-based M&S applications
- COA tool example
- Cloud Computing
- Conclusion

Command and Control

- An integral military process: people, sensors, doctrine, communications, machines, and decision aids.

- Creates ***Perceptions*** to the user of both own "Blue", enemy "Red" and other "white", "grey" etc.

- Purpose is to inform command of the operational military (and other) situation and to assist in making decisions based on information collected, processed and conveyed/displayed to the decision-maker.

- Allows the exercise of command in the context of an operation.

"Command and control is the means by which a commander recognizes what needs to be done and sees to it that appropriate actions are taken. "

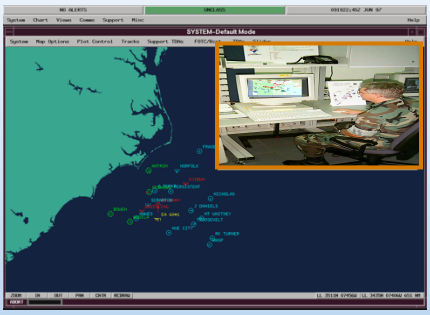
C2 "Systems" Historical Development

- "Map"-based fusion of information in an operating theater

- Hand drawn, focusing on sensor information
  - Maps, Maneuvering Board, Air Plot displays…

- Sea, then Air Warfare shortened timelines; introduction of electronic sensors; then displays to:
  - Utilize increased "range" of sensors around own unit
  - Decrease reaction/processing time to speed decision cycles to time critical threats
  - Network information in own unit, then between units

Operational Picture



Geospatial Data Fusion

Electronic Map Format
- Time/History animation
- Real-Time display

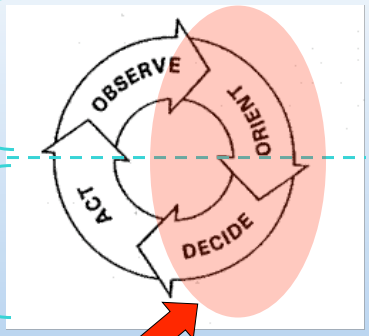
Geospacial "Drill-Down"
- Track Data
- Logistics
- Intelligence

Situational Awareness is provided to the user (and decision-maker) by processing a developed perception of the battlespace, and presenting it with supporting information in an easy to comprehend geographical format.

C2 Observe Orient Decide Act model

Sensors, Operational Picture
Situational Awareness

Decision support/COA
Execution capabilities



Opportunity space for M&S capabilities integrated with C2 systems:
- Sensor data fusion/synthesis
- Modeling of environment/operations/intelligence etc
- Training and planning/execution monitoring/control

C2 Decision Support tools

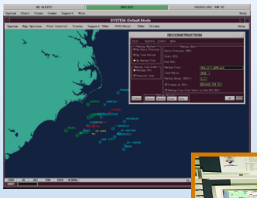
Required Characteristics:

- Powerful M&S “engines”
- Need for access to varied COI Databases
  - Timeliness- “Live” information
  - Using DoD Data-Sharing paradigm
- Display results in Operational Picture(s)/Domains
- Deployability with operating forces
  - Configuration managed with C2
  - External databases/COI reach back not essential
- Ability to interact with C2 plans/operational scenarios

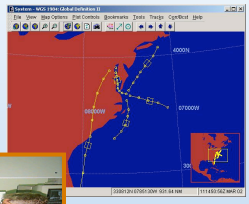
“Seamless” movement between time bases

- Full integration with C2 MMI in operational use

Enhancing Situational Awareness in C2 systems



Real-Time Operational Picture



Future/Past View

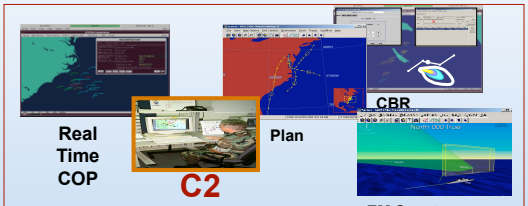
Time projection review view

Real-Time Picture + Time projection/analysis

Integrated Planning/Analysis in the operational picture for:

- Planning
- Training
- COA/analysis tools
- Geospatial Information
- Hazard prediction
- Sensor coverage
- Intelligence analysis

Adaptable C2 Operational Domains

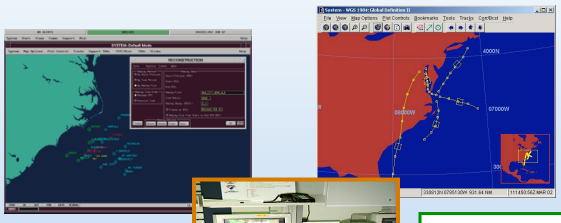


Complementary "Operational Pictures"

- Overlays (time projected activity)
- Inserted objects (CBR "Clouds")
- Other views of battlespace:
  - **EM space**
  - **Acoustic space**
  - **IW space**
  - **Network space**

- **Information/processes beyond human cognition**
- **Geospacial information other than track data**
  - **May be multidimensional (2-3D plus time)**
  - **Displayed in C2 as adjunct data/objects overlays**
  - **Displayed in Operational Picture as alternate views in:**
    - **Time base**
    - **Visualization (3-D etc.)**
    - **Function (control/analysis/planning)**

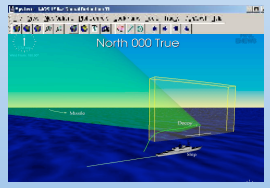
Adaptable C2 Operational Domains



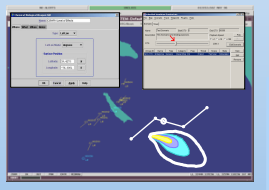
Plan Domain

Real-Time Operational Picture

Geospatial Information in Modeling and Simulation Generated C2 Operational Domains



EM Spectrum Domain



CBRNE Domain

Implicit requirements for M&S-Based capability in all transformational net-centric concepts, doctrine, programs and initiatives

Adaptable C4I Operational Domains

- Information may be:
  - "Layered" onto Operational Picture
    - I3; appended information to 2-D track like objects
  - Require unique geospatial display
    - EM spectrum; 3-D display of all radar and ESM activity
  - Both
    - CBR application; 2-D representation of "cloud" in 2-D OP, 3-D window showing altitude characteristics of cloud
- Domain viewed "real-time" with traditional OP
  - Separate window with unique characteristics slaved to 2-D OP display
- Domain used "non-real" time to access situation with respect to courses of action and operational plans

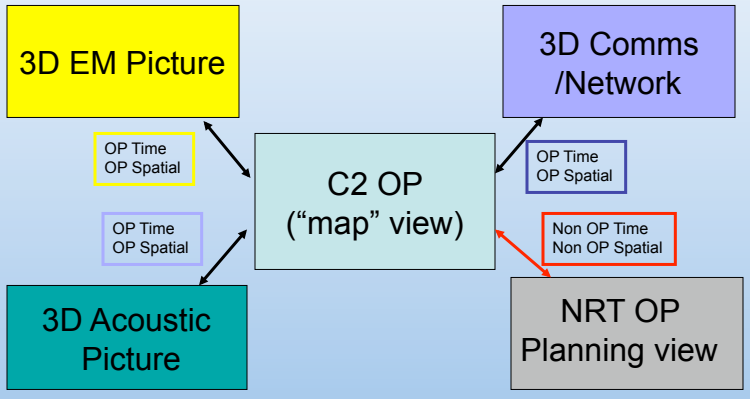
"Synthetic" Operational Picture

Situational awareness of information and processes beyond human cognition in "raw" state (M&S based results)

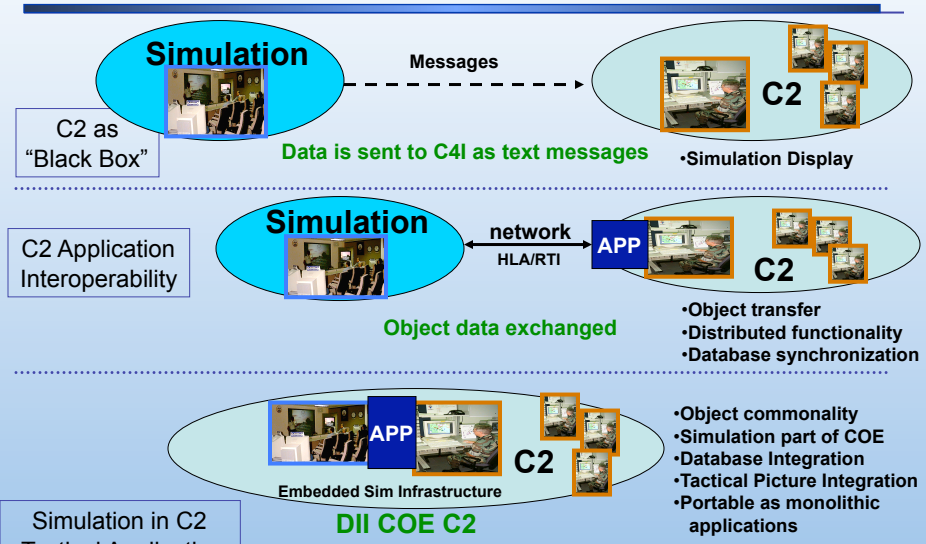
Geospatial information other than track data

- May be multidimensional (2-3D plus time)
- Common mission domains:
  - Acoustic (ASW etc)
  - Electromagnetic (EW, sensor coverage etc)
  - CBR (fallout/contamination clouds)
  - Information Assurance (operational network monotoring)
  - Information Warfare
  - Logistics
  - Intelligence
  - High-Level Data fusion/Sensemaking (Net-Centric data sharing)

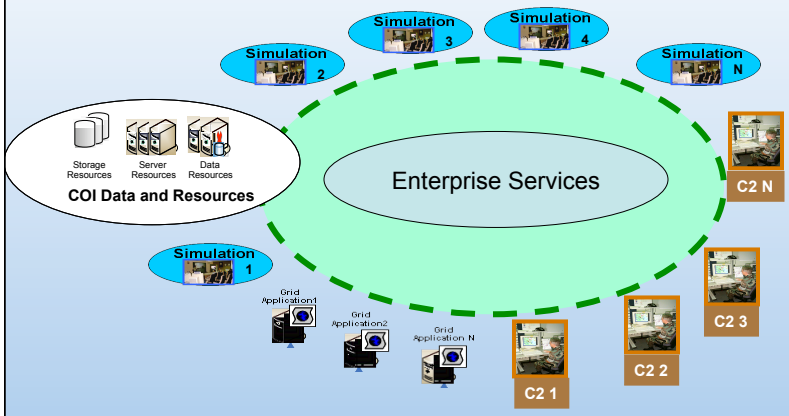
"Synthetic" Operational Picture (OP) examples



Stages of C2/Simulation Interoperability

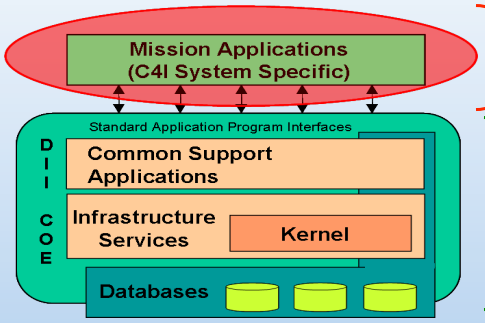


Simulation Services in an SOA as "Service-Based Applications"



Simulations, Enterprise Applications, C2 systems all operate as "Service-Based Applications", utilizing COI data and applications and Enterprise Services.

Simplified DII COE / C2 Architecture



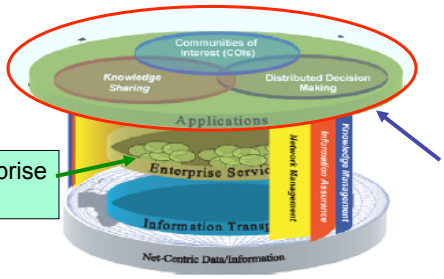
Mission Apps are COI supported, and have same function in a C2 SOA

DII-COE (or similar) type systems provide much the same support to MA's as Enterprise services in a SOA

Mission Apps are the perfect target for conversion to Service-Based Applications supported by C2 SOA services, and distributed platform and location independently.

"Service-Based Applications" In NCOE Construct

"NCOE applications enable pervasive knowledge generation and sharing throughout the Joint Force by providing users with a doctrinally and architecturally unconstrained interface and individually configurable access to enterprise resources."



SOA Enterprise services

Service-Based Applications composed of COI resources. Distributed throughout a SOA and supported by:
- COI and core Enterprise services
- Information Transport and Computing Infrastructure

May be legacy applications re-configured as service-based applications or new applications composed of many disparate services in the SOA

"Service-Based Applications" In NCOE Construct

Applications in the NCOE will enable pervasive knowledge by:

- ***Customizing the discovery, access, fusion, processing, and display of tailored information based on mission objectives and the role of the individual;***
- ***Providing collaborative tools for dynamic planning and execution that leverage enhanced situational awareness of the battlespace, smart decision tools, machine-to-machine interfaces, and shared knowledge;***
- ***Optimizing the ability of warfighters to share situational understanding including quickly assessing the situation and alternative courses of action;***
- ***Supporting adaptive, distributed, cooperative, and collaborative decisionmaking with tools and system integration;***
- ***Supporting appropriate organizational relationships across and beyond the Joint Force;***
- ***Continuing to operate even while disconnected from network resources;***
- ***Allowing application to application interchange/exchange when time sensitivity precludes access of centralized network resources.***

Challenges

Simulation Issues in operational use:

- Managing simulation data
  - Flexible time bases and management
  - Protecting normal operations
  - Fusing synthetic data with “real” data
- Utilizing “value added” simulations to the Warfighter for C2
- Configuring simulations as SOA based “service-based applications” and SOA services
- VV&A for operational use
- Ontology synchronization with C2 and operational users
- Distilling unique M&S requirements from top-level user requirements

COA Tool Example

➢Transiting vessel gets report of air WMD detonation by NBC message Conventional doctrine is upwind, MOPP4 for considerable distance then wait a prescribed time and test before resuming a course to destination and relaxing defensive posture

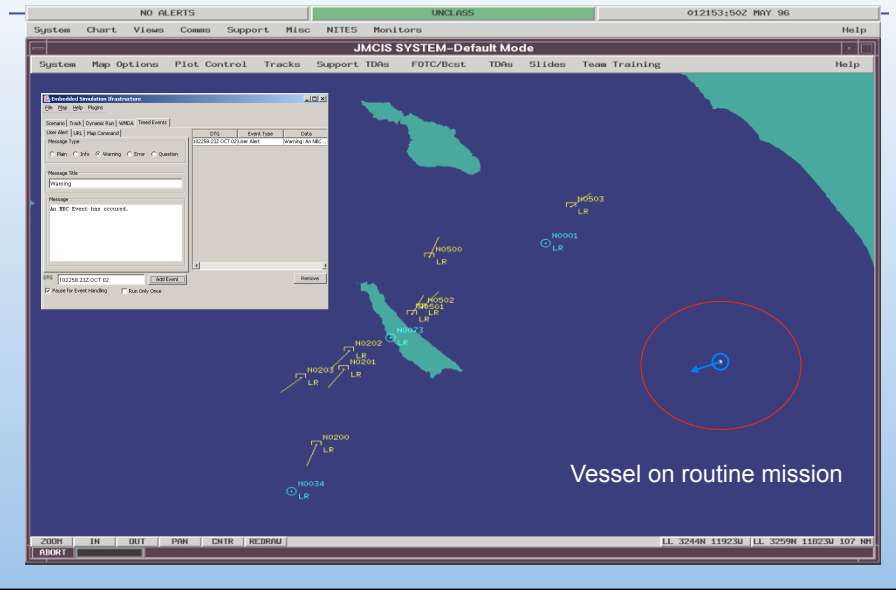
➢Simulation-based WMD contamination “cloud” COA tool in C2 operational picture gives estimates of contamination and movement.

➢ Use of WMD COA tool would give adequate warning and prediction to easily change projected movement to avoid “cloud” without mission degradation as would conventional doctrine.

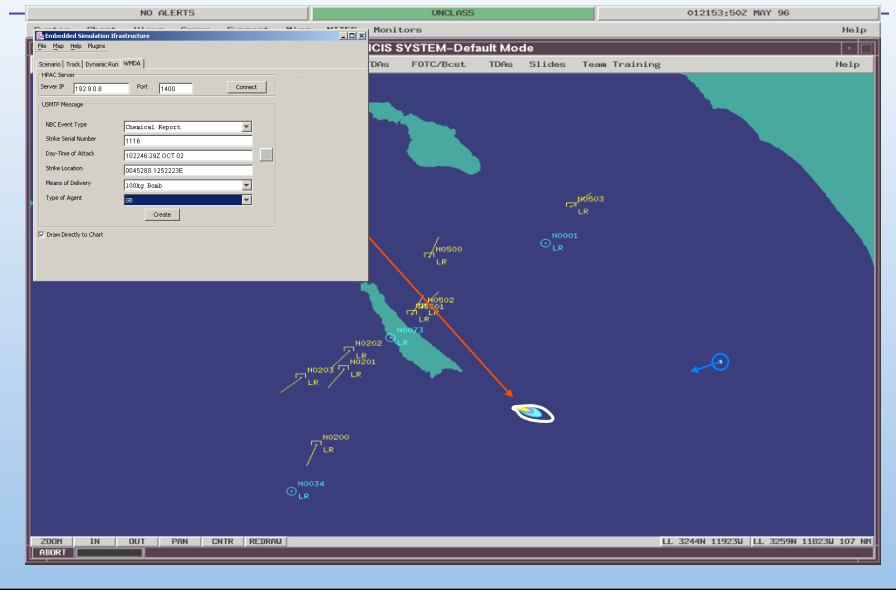
➢ Use of tool would help in setting mission defensive posture for limited and effective time vice with no prediction.

➢Use of tool would enhance mission posture, and keep to operational plan.

USMTF NBC Message Received and Processing

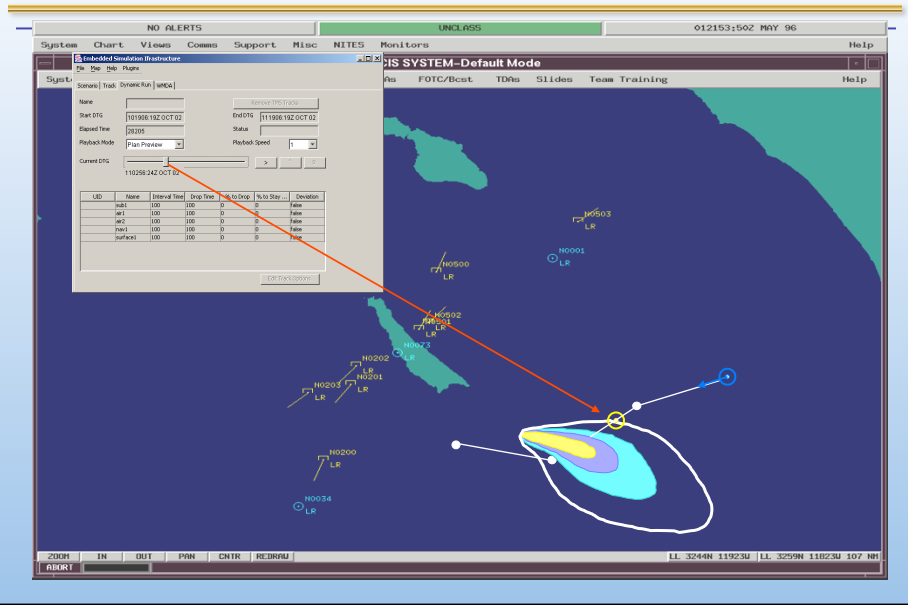


Contamination Cloud Computed by Sim and Entered into OP



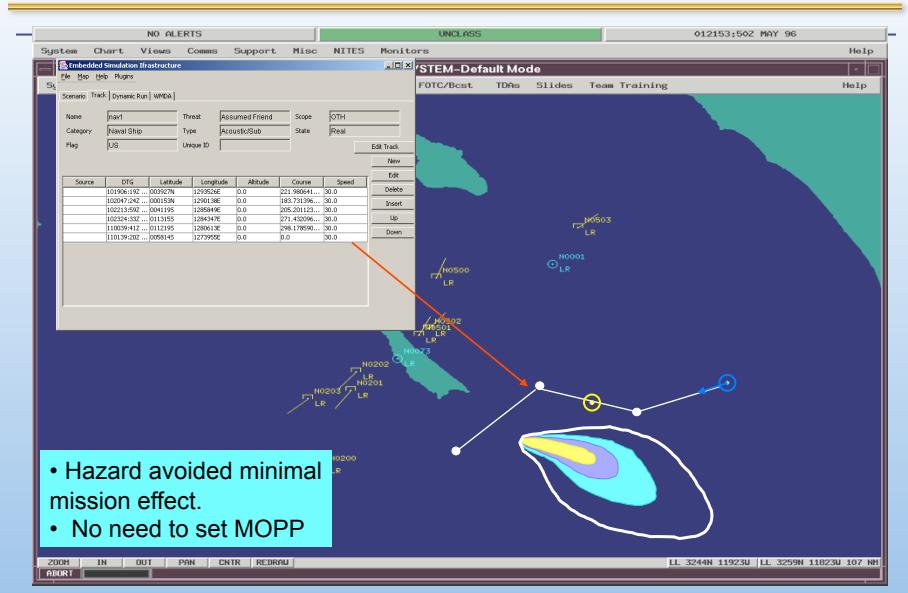
Time Projection Analysis:

Vessel Movements & Contamination Cloud Predictions.



COA Analysis

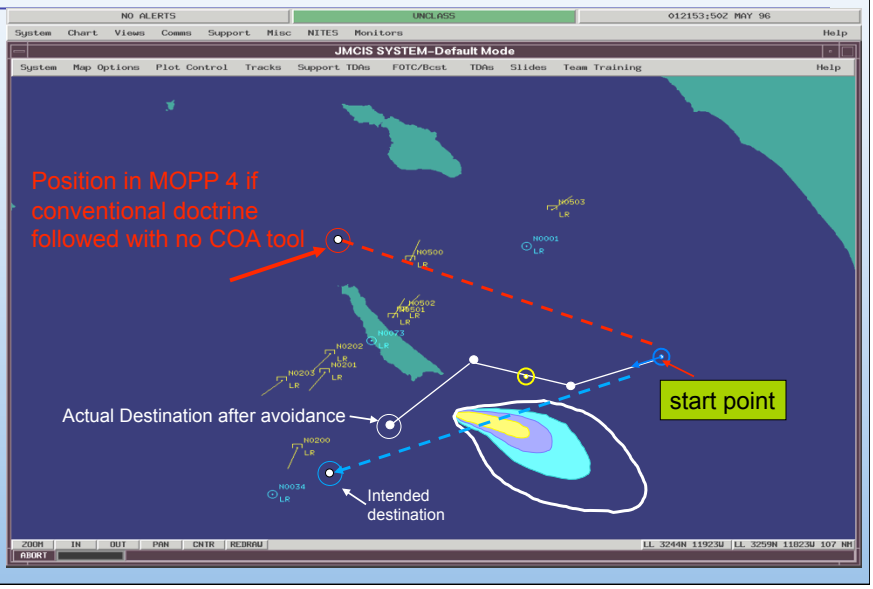
Modify the Path of Intended Movement (PIM).



- Hazard avoided minimal mission effect.
- No need to set MOPP

Effectiveness

Comparison of mission effect with and without COA tool



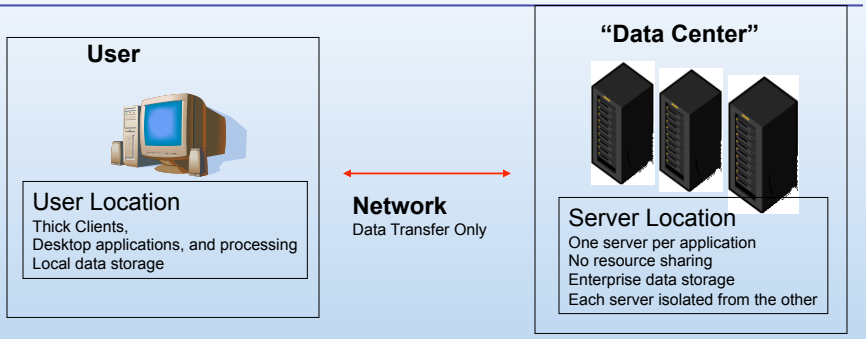
What is "Cloud" Computing

A network-based, distributed computing infrastructure consisting of computing services (data storage, processing, application hosting) delivered through virtual computing nodes built with processing and storage virtualization technologies. Data, processing, and application functionality are provided to users as a service, without knowledge of, or control over the technology or infrastructure that supports them.

Cloud computing can include the following operational paradigms:

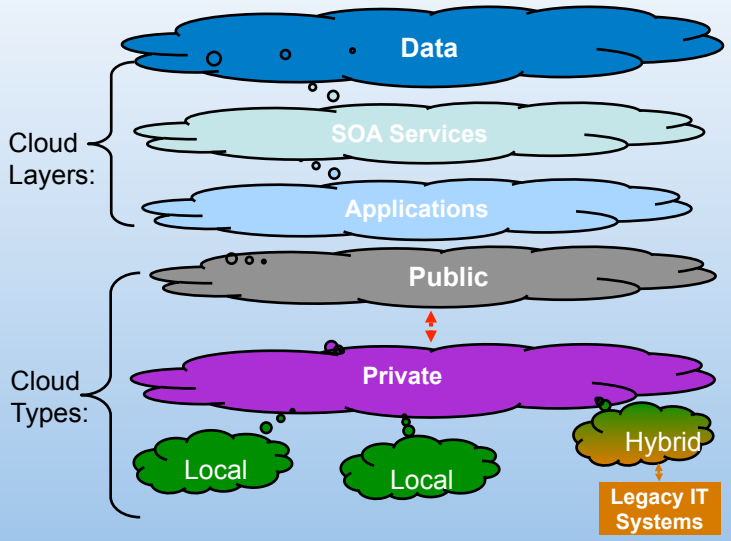
- **Virtualization** of Infrastructure
- **Utility/capacity computing** business models
- "**Thin-Client" application delivery** architectures and hardware
- **Data Center virtual application/services hosting**, (including legacy applications) in a shared computing and storage "pool" expanded modularly
- **Public or Private Clouds**
- **"Enterprise" Clouds**
- **Local, "Tactical" Clouds**

Present C2 Client-Server Architecture

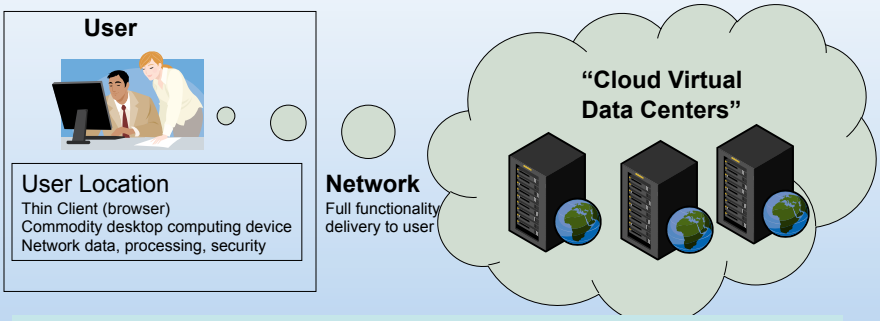


- Utilizes network for Data transfer only
- Many unsynchronized copies of client applications in disparate locations
- Desktop limited by local storage and processing power
- Data center has pre-allocated servers to applications, no sharing or flex
- Many user application/data locations for security gaps
- High touch labor cost to desktop thick clients
- Data center "Balkanized" silos of application hosting capability

Various Cloud Representations

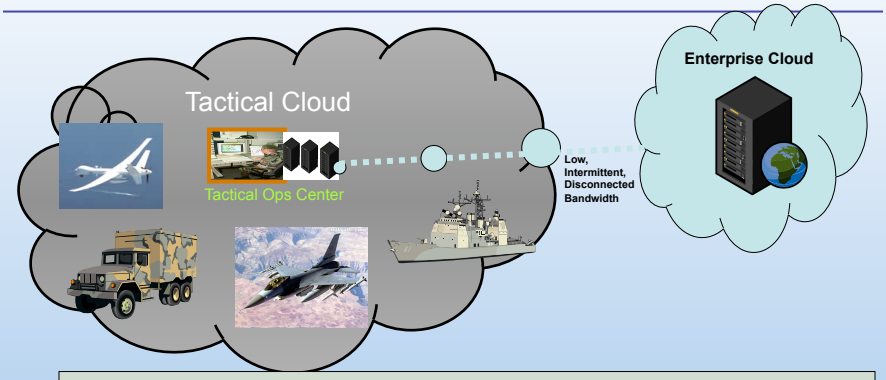


Notional Cloud Computing Architecture



- Virtualized architecture
- Dynamic resource sharing
- Enterprise data storage
- Enterprise applications/services delivery to user
- Increased security (removes vulnerabilities from desktop)
- Reduced costs (local "touch" labor, software licenses, costly desktop full computing systems)
- Increased reliability, network control and redundancy
- Allows users full apps/data access from any desktop, not dedicated machine

Notional Tactical "Cloud"



- Cloud computing moves the applications, data, and computing now done on discrete workstations and desktops to a modular, shared computing tactical cloud
- Tactical IT 'footprint", power and maintenance are reduced, total computing power is increased for tactical, computing intensive apps not tactically available in conventional architectures.
- Tactical cloud utilized combat systems data links and tactical comms internally, can be disconnected from enterprise and perform mission
- When robustly connected full enterprise capability to Tactical Ops center

Conclusions

- **Simulations can and will be used in C2 as services** (already part of all major concepts and net-centric strategies). Need to align M&S sponsorship, development and advocacy to C2 operational concepts and strategies.
- **Need to educate C2/operational community on use of M&S** to accommodate their top-level capability needs, and to 'socialize" M&S in the operational environment, beyond "offline" analysis and training role.
- **Need to Integrate C2 development into emerging SOA operational architectures** and conceptually configure high level C2 user applications as composable groups of C2 SOA services: "service-based applications" when accessed at the user level, as COI "services" when supporting other user applications.
- "**Cloud Computing" is going to happen** for economic, policy and security reasons at the enterprise level, need to leverage the benefits for mission support at the tactical level.
- **Need to decouple "Public" and "Private" Clouds** from the cloud computing discussion to enable leveraging the hardware and software advances in public cloud computing for military use
- **Cloud Computing is a means to extend the benefits of enterprise M&S** based decision C2 service-based applications to the tactical environment for integration into operational CONOPS and doctrine.
- **Robotic sensor/forces integration will be a driver** for these new tactical capabilities.