Program Executive Office
Command, Control, Communications, Computers and Intelligence (PEO C4I)

Technical Framework for Cloud Computing at the Tactical Edge

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STATEMENT A: Approved for public release, distribution is unlimited (14 JANUARY 2013)
PEO C4I Organizational Structure

CNO
Chief of Naval Operations

SPAWAR
RADM Patrick Brady
VICE DEPUTY

APEO Contracts (2.0)
APEO Installations (FRD)
APEO Logistics (4.0)
APEO Engineering (5.0)
APEO S&T (7.0)

SPAWAR Space
Field Activity

SCC Atlantic

SSC Pacific

SPAWAR Field Activity

CURRENT READINESS REPORTING

ASN(RDA)
Assistant Secretary of the Navy
(Research, Development & Acquisition)

PEO C4I
RDML C. D. Becker
EXECUTIVE DIRECTOR
Ms. Ruth Youngs Lew

Chief of Staff
DPEO Acquisition Management
DPEO Manpower & Budget
DPEO Strategic Mgmt & Process Improvement
DPEO Platform Integration & Modernization
DPEO Technical Direction & Program Integration

Battlespace Awareness & Information Operations
PMW 120
NIDE

Information Assurance & Cyber Security
PMW 130
NIDE

Command and Control
PMW 150
NIDE

Tactical Networks
PMW 160
NIDE

Communications
PMW 170
NIDE

International C4I Integration PMW 740
NIPO

Carrier and Air Integration PMW 750
NAE

Ship Integration PMW 760
SWE / NBMDE

Undersea Integration PMW 770
USE

Shore and Expeditionary Integration PMW 790
NECE / NBMDE

CURRENT READINESS REPORTING
Vision, Mission, and Strategic Goals

- **Vision**
  Information Dominance: Anytime, Anywhere…

- **Mission**
  Provide integrated communication and information technology systems that enable information dominance and the command and control of maritime forces

- **Strategic Goals**
  - Minimize Cost, Deliver Capability
    “Minimize total ownership cost, while delivering integrated C4I capabilities”
  - Rapid Capabilities to the Warfighter
    “Foster focused innovation to rapidly field relevant capabilities to meet existing and emerging Warfighter needs”
  - Develop Workforce, Achieve Excellence
    “Develop an aligned, agile workforce equipped to achieve acquisition excellence in a dynamic environment”
About PEO C4I

Workforce
- Civilian: 244
- Military: 69

FY12 Total Obligation Authority (based on PB12)
- Research & Development: $339M
- Procurement, Navy: $1.2B
- Operations & Maintenance, Navy: $453M
- Ship Conversion, Navy: $333M
- Foreign Military Sales: $81M

Programs - Total: 122
- ACAT I: 7*  ACAT II: 6  ACAT III & Below: 109**

*N Includes: ACAT IAM and ACAT IAC Programs
**Includes: 1 Rapid Deployment Capability Program

Platforms Programmed for Support – FY11
- Afloat: 243  Shore: 322  Expeditionary: 21

Navy C4I Key Facts
- More than 5,200 radios fielded
- More than 2,500 annual installations
- More than 700 applications supported
- Average/fielded bandwidth capability
  - Carrier: 10Mbps – 24 Mbps
  - Destroyer: 2 Mbps – 16 Mbps
  - Submarine: 128Kbps – 1.5 Mbps

Average technology refresh
18 months

Average time to market
Initial fielding: 36 months
Full Fielding: 8-10 years

Updated: November 2011
**Problem:** The Navy requires an efficient and cost effective means to govern, manage, process, and exploit dramatic increases in Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) data ashore and afloat.

**Solution:** This brief outlines implementable approach to address the data problem within the context of the Navy’s tactical edge C4ISR environment in order to deliver improved C4ISR warfighting capabilities ashore and afloat. It identifies:

- Target Cloud Vision for the Tactical Edge
- Experimentation and Risk Reduction
- Investment Initiatives/Opportunities
Approach

• Background
• Capability Needs
• Capability Needs – Afloat and Ashore
• Assumptions and Constraints
• Best Practices:
  ➢ Cloud Computing
  ➢ “Big Data” Analytics
  ➢ Content Distribution Management
  ➢ Developer Ops
• Architecture components- Putting it together
• Deliverables
  ➢ Target Cloud Vision for the Tactical Edge
  ➢ Experimentation and Risk Reduction
  ➢ Investment Initiatives/Opportunities
• Summary
Capability Needs

- How to govern, manage, process, and exploit dramatic increases in C4ISR data ashore and afloat
  - How to boost information technology (IT) efficiency/utilization while lowering costs
  - How to align IT acquisition with fleet operational needs and rapidly deliver incremental capabilities
8 Needs total identified such as:

1. Faster, deeper, more precise search
2. Patterns of life & anomaly detection
3. Reduced demand/dependency on SATCOM

Specific Needs Identified:

- 2 Specific Needs Identified
- 3 Specific Needs Identified
- 4 Specific Needs Identified

Common Needs:

- Faster, deeper, more precise search
- Patterns of life & anomaly detection
- Reduced demand/dependency on SATCOM

Sensor/Platforms:

- Teleports
- CCOMs
- JIOCs
- MOCs
- NOCs
- TOCs

Afloat

Ashore

Dismounted

Mounted/Mobile

Transportable
Assumptions and Constraints

• Bandwidth is and will continue to be a chief constraint

• Additional assumptions and constraints were provided by OPNAV N2N6 (2011)
Best Practices

• **Cloud Computing**: a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources that can be rapidly provisioned and released with minimal management or interaction

• **“Big Data” Analytics**: the analysis services associated with managing and utilizing large-scale (i.e., TB- or even petabyte (PB)-level scale), diverse big data

• **Content Distribution Management**: a set of approaches and techniques for efficiently delivering network content, reducing the load on origin servers, and improving overall network performance

• **Development Operations (DEVOPS)**: a set of principles, methods, and practices for communication, collaboration, and integration between software development teams and operators
Cloud Computing

• NIST Definition

  “Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.”

Cloud Computing Concepts

• **Software As a Service (SaaS)**
  - Provides managed software applications to the end user.
  - Service Oriented Architecture (SOA) framework can deliver enhancements for software applications to communicate with each other.

• **Platform as a service (PaaS)**
  - Production and Development environments as a service
  - Clients build applications that run on the provider's infrastructure

• **Infrastructure as a Service (IaaS)**
  - Servers, software, data center space or network equipment abstracted from end user
  - Resources dynamically allocated

• **Data Storage as a Service (dSaaS)**
  - Provides data storage space as a service to the end user via a common network
  - Enables dynamic allocation of resources based on need
Cloud Challenges

- DIL Environment
- Bandwidth
- Manpower
- Training
- Performance
- Vendor Lock-in
- Reliability/Auditing
- Security
Hey AT&T customers: Your Facebook data went to China and S. Korea this morning...

March 22nd, 2011 by Barrett Lyon
Best Practices

- **Cloud Computing**: a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources that can be rapidly provisioned and released with minimal management or interaction.

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- **Development Operations (DEVOPS)**: a set of principles, methods, and practices for communication, collaboration, and integration between software development teams and operators.
“Big Data” Analytics

- **Description**: “Big Data” is a term that is applied to data sets whose size is beyond the ability of commonly used software tools to capture, manage, and process the data within a tolerable elapsed time (Wikipedia B. D., 2001). “Big Data Analytics” is a general term that covers the analysis services associated with managing and utilizing large-scale (i.e., TB- or even petabyte (PB)-level scale), diverse big data.

- **Solutions in this space address problems associated with**:
  - **Volume**: too much data
  - **Analysis**: correlating and interpreting large volumes of complex, diverse data
  - **Labor**: manpower is expensive; manual techniques can be inefficient or intractable at scale

- Solutions in this space tend to be complementary with cloud computing. By using cloud computing elements such as inexpensive commodity hardware, server virtualization techniques, and a software programming model such as MapReduce, organizations are able to rapidly process huge datasets in parallel on distributed computing clusters.

- Implementing these types of Big Data Analytics solutions provides an ability to store, process, and access large amounts of heterogeneous data (at TB- or even PB-level scale) while overcoming the challenge of drowning users in data by providing highly relevant data in response to queries. The paradigm shift is that operators/analysts now can search vast archives of data from reports and sensors and retrieve relevant information—enabling them to obtain answers to questions that were previously unanswered. These approaches are widely used within the commercial sector, and there have been successful implementations within the Intelligence Community as well.
“Big Data” Analytics Cont’d

- **Precedents:**
  - Google, Yahoo!, Facebook, Twitter, etc.
  - National Security Agency (NSA)
  - Office of the Director of National Intelligence (ODNI)-sponsored Information Integration Pilot (I2P)
  - Navy Research Lab (NRL)/Office of Naval Intelligence (ONI)
  - Distributed Common Ground System–Army (DCGS-A)

- **Implications and benefits include:**
  - **Automation:** Automatically correlating data based on explicit and implicit relationships within that data
  - **Historical Analysis:** Ability to look across accumulated sets of data over time to uncover important trends or insights from past events
  - **Anomaly Detection:** Quick discovery of unexpected events, actions, or behaviors that deviate from known trends
  - **Predictive Analytics:** Ability to process C4ISR datasets to determine likely events, actions, or behaviors
  - **Behavioral Trends and Patterns of Life:** Ability to execute actor-centric behavior models to produce likely actor intentions and actions
  - **Alerts, Warnings, and Indications:** Quicker turnaround from processing and exploitation to produce actionable information for the Navy’s C2.
  - In this space, cost points are based on speed-to-capability.
Cloud Computing Differences

Utility Cloud Computing Options

- **Software-as-a-Service (SaaS)**
  - Google
  - Microsoft Office 365

- **Platform-as-a-Service (PaaS)**
  - Windows Azure

- **Infrastructure-as-a-Service (IaaS)**
  - Amazon Web Services
  - Rackspace
  - Terremark

Intelligence Community Approach

- **Virtualization (Multi Instance) Architecture**
- **Private Cloud (JWICS/SIPR)**
- **OZone**
- **BigTable/HBase**
- **MapReduce**
- **Hadoop**
- **HW**

- **Multitenancy Architecture**
- • Single instance of SW servicing many clients
- • Share same OS, same HW, with same data storage

- • Separate software set up for different client organizations
- • Different OS, different data storage different HW
Best Practices

- **Cloud Computing**: a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources that can be rapidly provisioned and released with minimal management or interaction.

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- **Content Distribution Management**: a set of approaches and techniques for efficiently delivering network content, reducing the load on origin servers, and improving overall network performance.

- **Development Operations (DEVOPS)**: a set of principles, methods, and practices for communication, collaboration, and integration between software development teams and operators.
**PEO C4I Solution Space:** Reduce SATCOM saturation.

**Description:** Content Distribution Management is a set of approaches and techniques for efficiently delivering network content, reducing the load on origin servers, and improving overall network performance. Content Distribution Management involves caching and distributing content by placing it on content servers, which are located near users and can scale with changes in demand. Its benefits can be realized on both afloat-to-ashore and ashore-to-afloat data traffic.

**Solutions in this space address problems associated with:**
- **Inefficient use of bandwidth:** Sending the same redundant data multiple times generates unnecessary traffic.
- **Latency:** The greater the physical distance between users and data, the greater the latency.
- **Hits:** Surges of network traffic can result in Denial of Service at the host.

**Precedent:**
- DISA has implemented a managed-service version of the commercial Akamai Content Delivery Network. DISA’s implementation is known as the Global Information Grid (GIG) Content Delivery Service (GCDS) and has been running on Defense Information Systems Network (DISN) for five years. GCDS is now distributed worldwide.
Data Cloud – Content Distribution Network
Best Practices

• **Cloud Computing**: a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources that can be rapidly provisioned and released with minimal management or interaction.

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• **Development Operations (DEVOPS)**: a set of principles, methods, and practices for communication, collaboration, and integration between software development teams and operators.
Development Operations (DEVOPS)

- **PEO C4I Solution Space:** Employ an agile development and deployment paradigm; co-locate software developers with fleet operators/analysts.

- **Description:** DEVOPS is a set of principles, methods, and practices for communication, collaboration, and integration between software development teams and operators. The intent is to provide a more collaborative and productive relationship between development teams and operations teams. This improved relationship and collaboration increases efficiency in requirements generation, aligns software development activities with prioritized operational needs, increases operational perception of IT responsiveness, reduces the production risk associated with frequent changes, and introduces quality assurance testing throughout development activities.

- The basic premise is that more frequent and smaller changes, driven by operational priority and informed by direct, frequent feedback from operators, results in less risk to and higher quality of software deployments. Organizations without DEVOPS often see problems emerge from the lack of direct communication between development teams and operational teams. The adoption of DEVOPS is being driven by the use of agile software development processes, operational demand for an increased rate of production releases, and automation.
Approach - Revisited

- Background
- Capability Needs
- Capability Needs – Afloat and Ashore
- Assumptions and Constraints
- Best Practices:
  - Cloud Computing
  - “Big Data” Analytics
  - Content Distribution Management
  - Developer Ops
- Architecture components - Putting it together
- Deliverables
  - Target Cloud Vision for the Tactical Edge
  - Experimentation and Risk Reduction
  - Investment Initiatives/Opportunities
- Summary
Architecture Node Discussion

- Core Nodes (Ashore)
  - An example is the Maritime ISR Enterprise (MIE) cloud that is being stood up at various sites
  - Reside ashore
  - Highest storage, processing, surge capacity within the Navy
  - Serve as reachback for Deployable and Edge Nodes
  - Provide enterprise-level IaaS, PaaS, and SaaS

- Deployable Nodes (Afloat and Ashore)
  - Operational-level cloud
  - Afloat: Initial point of ingest for force/group-level organic afloat sensors
  - Potential point of ingest for shore-based assets
  - Ashore: Initial point of ingest for operational sensors ashore
  - Ride on shipboard infrastructure (IaaS/PaaS/SaaS)
  - Provide less storage capacity/computing resources than Core Nodes but more than Edge Nodes
  - Provide sustained services to afloat force/group-level users under DIL and A2AD conditions
  - Mission tailored.

- Edge Nodes (Afloat and Ashore)
  - Initial point of ingest for unit-level organic Navy sensors
  - Ride on shipboard infrastructure (IaaS/PaaS/SaaS)
  - Provide less storage capacity/computing resources than Core and Deployable Nodes
  - Provide sustained services to afloat unit level users under DIL and A2AD conditions
  - Mission tailored.
# Architecture Node - Components

<table>
<thead>
<tr>
<th>Configuration Components</th>
<th>Fixed Enterprise Ashore (Core Node)</th>
<th>Forward-deployed Ashore (Deployable Node)</th>
<th>Force/Group Level Afloat (Deployable Node)</th>
<th>Expeditionary Units Ashore Or Tactical Units Afloat (Edge Node)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Picture</strong></td>
<td><img src="image1" alt="Theater Area of Responsibility (AOR)" /></td>
<td><img src="image2" alt="Tactical AOR" /></td>
<td><img src="image3" alt="Operational AOR" /></td>
<td><img src="image4" alt="Tactical AOR" /></td>
</tr>
<tr>
<td><strong>Scope</strong></td>
<td>Theater Area of Responsibility (AOR) Strategic Area of Concern (AOC)</td>
<td>Tactical AOR Operational AOR</td>
<td>Operational AOR Theater AOC</td>
<td>Tactical AOR</td>
</tr>
<tr>
<td><strong>Physical Module</strong></td>
<td>4+ racks (scalable)</td>
<td>20’ cargo container (4 racks/container)</td>
<td>2-4 racks Deployed on CANES</td>
<td>½ rack (Transport case, Fly-away box, &quot;Pod&quot;)</td>
</tr>
<tr>
<td><strong>Cloud Service Model</strong></td>
<td>SaaS PaaS IaaS</td>
<td>SaaS PaaS IaaS</td>
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</tr>
<tr>
<td><strong>Connectivity</strong></td>
<td>Normal</td>
<td>Normal to DIL</td>
<td>DIL (except when docked)</td>
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</tr>
<tr>
<td><strong>WAN Bandwidth</strong></td>
<td>≥ 1 gigabit per second (Gbps)</td>
<td>128 kilobits per second (kbps) – 100 megabits per second (Mbps)</td>
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<tr>
<td><strong>Latency</strong></td>
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<td>Med to High</td>
<td>High</td>
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<td><strong>IT Capability Hardware</strong></td>
<td>1+ PB storage 2000+ cores</td>
<td>1 PB storage 2000 cores</td>
<td>500 TB storage 1000 cores</td>
<td>100 TB storage 200 cores</td>
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<tr>
<td><strong>Baseline Capability (Any software needed to run this software is implied in this list)</strong></td>
<td>AIF Analytics C2RPC Accumulo GCDS WAN Acceleration Hadoop OWF</td>
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Breakdown of Core and Deployable Nodes
Breakdown of Edge and Deployable Nodes
Problem: The Navy requires an efficient and cost effective means to govern, manage, process, and exploit dramatic increases in Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) data ashore and afloat.

Solution: This brief outlines implementable approach to address the data problem within the context of the Navy’s tactical edge C4ISR environment in order to deliver improved C4ISR warfighting capabilities ashore and afloat. It identifies:

- Target Cloud Vision for the Tactical Edge
- Experimentation and Risk Reduction
- Investment Initiatives/Opportunities
## Deliverable #1: Target Cloud Vision for the Tactical Edge

![Cloud Architecture Diagram]

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## Deliverable #1:
**Target Cloud Vision for the Tactical Edge**
**Needs Traceability**

<table>
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<tr>
<th>Operational Needs</th>
<th>As-Is Architecture</th>
<th>Conceptual Target Architecture</th>
<th>Aggregate Enablers of Conceptual Target Architecture</th>
<th>Best Practices</th>
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<tbody>
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<td>Common</td>
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<td>Capability Needs</td>
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<td>Ashore</td>
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Deliverable #2:
16 Short Term Experimentation and Risk Reduction
(Examples)

Example #1:
Ingest Data into Accumulo. As Accumulo adoption grows within the Navy and becomes a foundational element of the Navy’s Information Dominance Strategy, it will be necessary to develop metrics on how much effort is required to ingest existing data from legacy systems to an Accumulo instance.

- **Outcome**: An understanding of the level of effort required to ingest data from existing systems into Accumulo
- **Best Practice Area**: “Big Data” Analytics

Example #2:
Exercise GCDS Afloat. There are various IA and engineering policies in place that ensure shipboard DNS queries are resolved to the shore based NOCs. These policies prohibit operation of GCDS afloat. The GCDS Program Office would like to work with Navy to work toward placing GCDS edges on ships.

- **Outcome**: Requirements for GCDS to support Content Distribution Management between the afloat and ashore environments
- **Best Practice Area**: Content Distribution Management
## Deliverable #3: Potential Future Investments

<table>
<thead>
<tr>
<th>Investment Areas</th>
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<tbody>
<tr>
<td>“Big Data” Solutions</td>
</tr>
<tr>
<td>Cloud Computing</td>
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<tr>
<td>DEVOPS</td>
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<tr>
<td>Content Distribution Management</td>
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<tr>
<td>Other</td>
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Summary and Conclusions

• This brief outlines implementable approach to address the data problem within the context of the Navy’s tactical edge C4ISR environment in order to deliver improved C4ISR warfighting capabilities ashore and. It identified:
  ➢ Target Cloud Vision for the Tactical Edge
  ➢ Experimentation and Risk Reduction
  ➢ Investment Initiatives/Opportunities

• This approach should be verified and validated through experimentation and risk reduction efforts

• Outcomes of experimentation and risk reduction should drive investments in FY14 and beyond.
We get IT.
We also integrate it, install it and support it. For today and tomorrow.