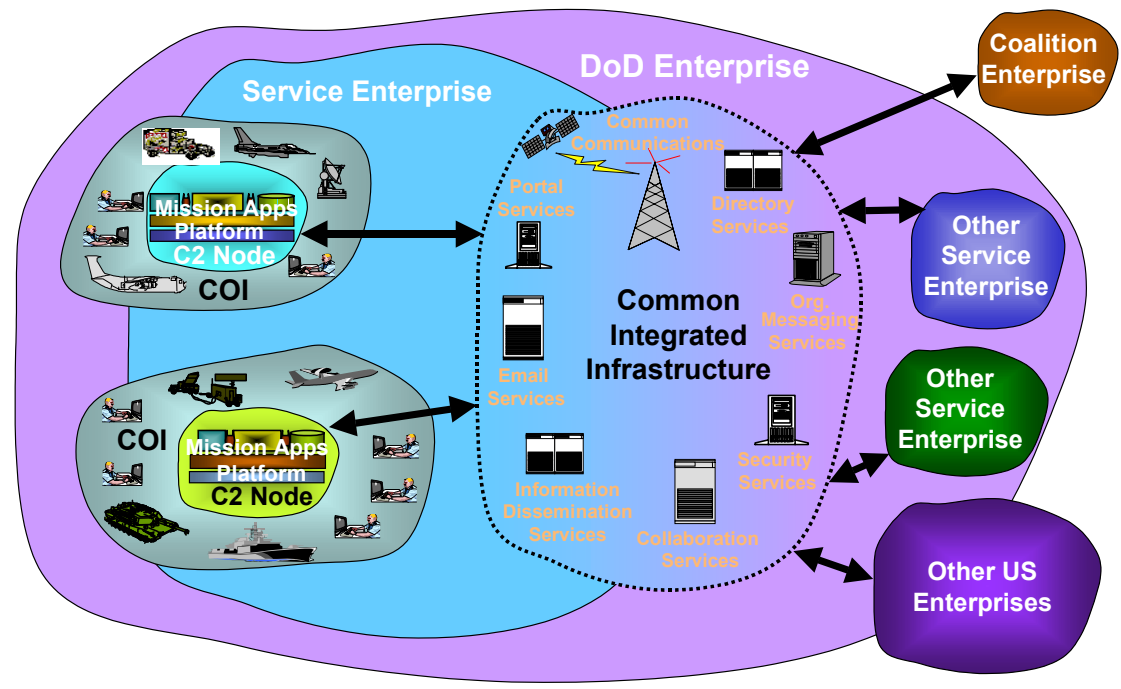# A Reference Architecture for Network-Centric Information Systems

**Dr. Scott Renner**
sar@mitre.org

**17 June 2003**

MITRE

# C2 Enterprise Reference Architecture (C2ERA)



- **What problem does C2ERA try to solve?**

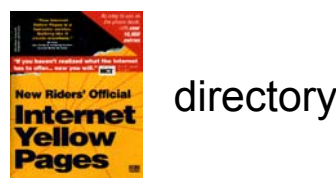- **What are the key aspects of the solution?**
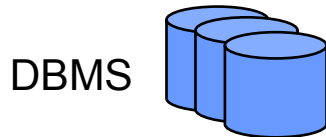
# What The Users Want



- **C2 users would like to have a single perfect C2 system**
  - **It does exactly what they need today**
  - **It's easy to change into what they need tomorrow**
  - **All users and all parts working together as a seamless whole**
  - **Affordable, on schedule, etc...**

- **We couldn't build that perfect system yesterday**
  - **And still can't today**
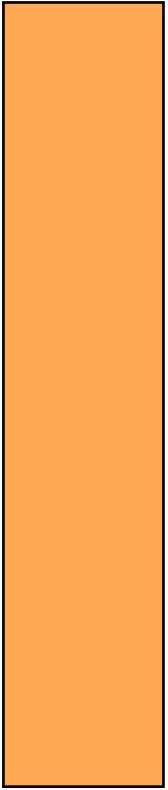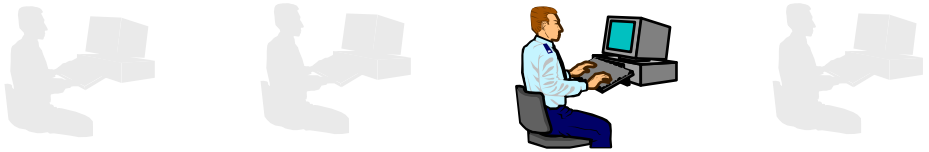
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# The Past Compromise

- **Instead, we organized the world into program offices that built separate C2 systems**

- **A program built a system for its users**

# The Past Compromise



**FUNCTION**

**INFRASTRUCTURE**

network

DBMS

directory

- **Instead, we organized the world into program offices that built separate C2 systems**

- **A program built a system for its users**
  - **All the mission functionality they wanted**
  - **All the infrastructure they needed**

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# The Past Compromise

- **Instead, we organized the world into program offices that built separate C2 systems**

- **A program built a system for its users**
  - **All the mission functionality they wanted**
  - **All the infrastructure they needed**
  - **Delivered as a single amalgamation**
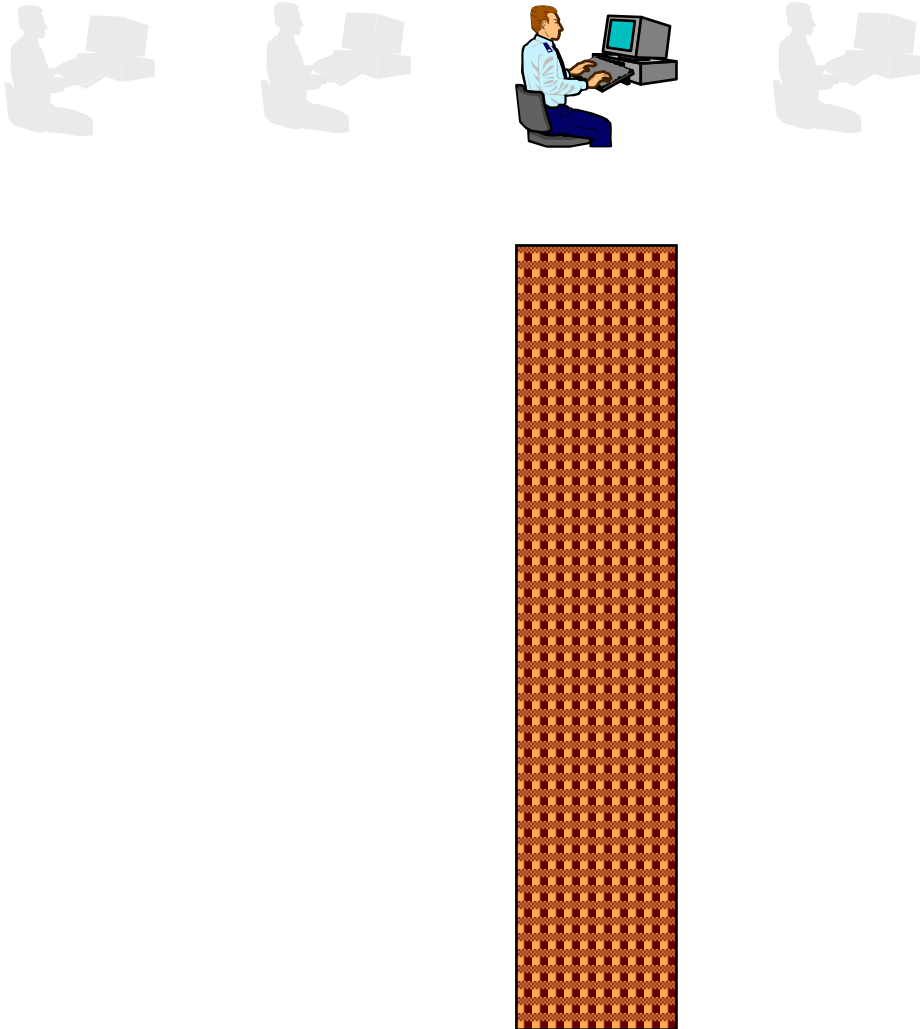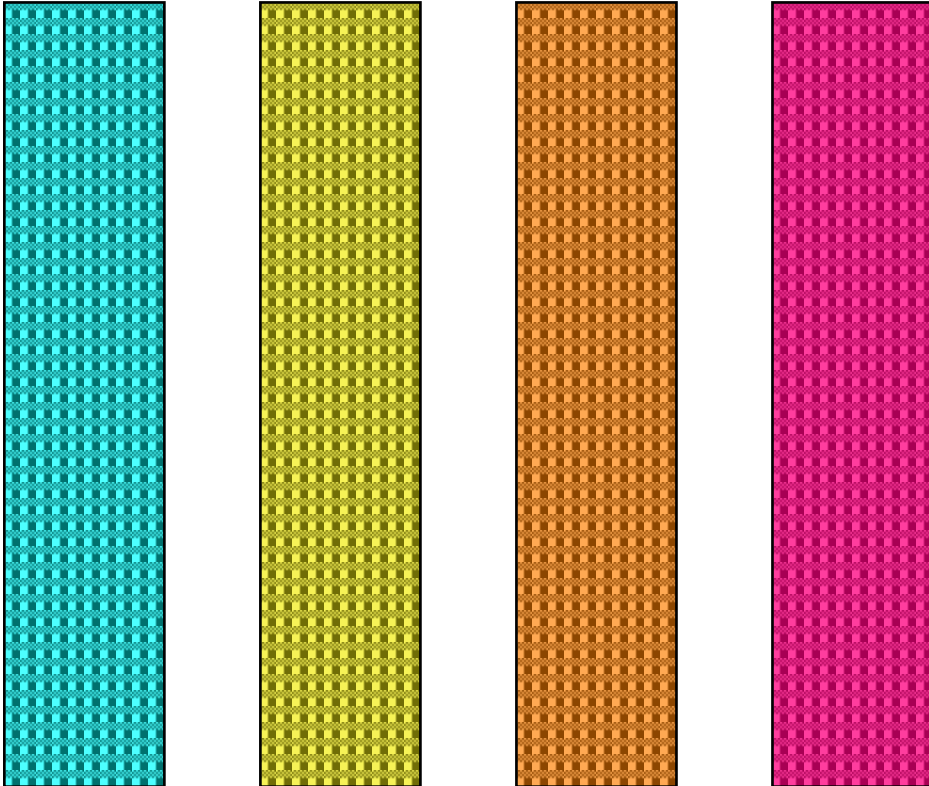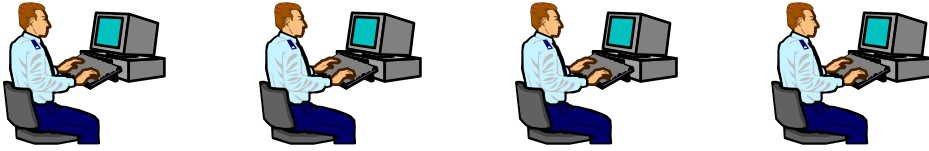
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# The Past Compromise

- **Instead, we organized the world into program offices that built separate C2 systems**

- **A program built a system for its users**
  - **All the mission functionality they wanted**
  - **All the infrastructure they needed**
  - **Delivered as a single amalgamation**

- **And other programs built other systems for other users...**

*Hundreds of C2 systems...*

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# A Forest Of Stovepipe Systems



**DoD Enterprise**

**Service Enterprise**

**Coalition Enterprise**

**Other Service Enterprise**

**Other Service Enterprise**

**Other US Enterprises**

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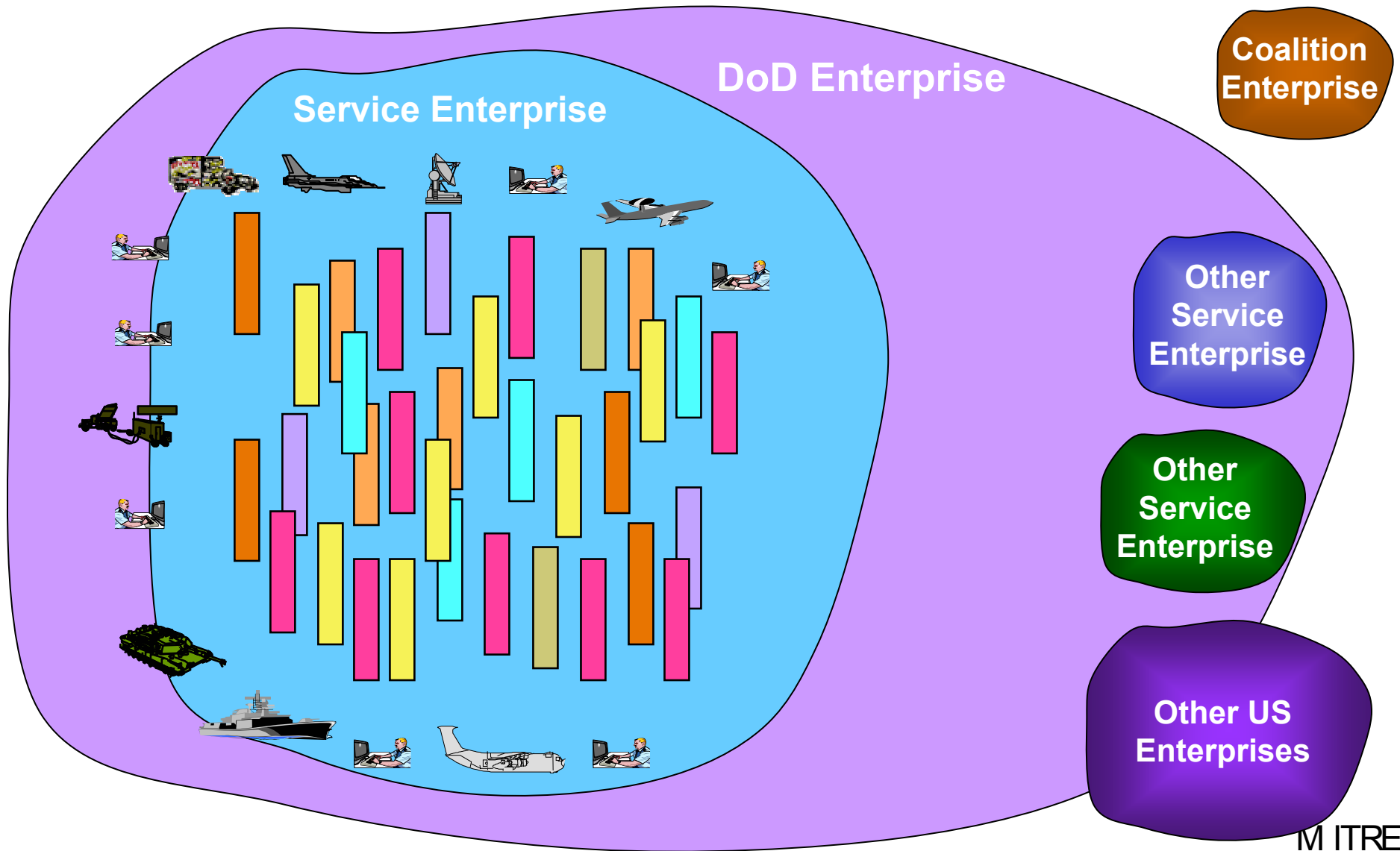
# The C2 Enterprise Integration Problem
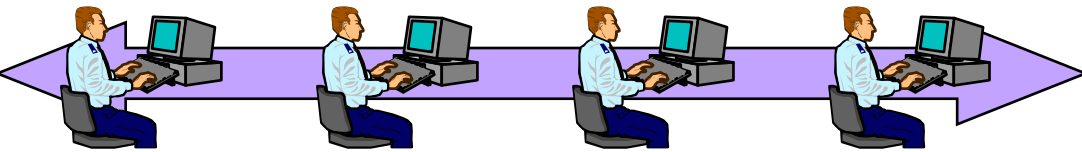
**It's difficult for these people to work together**
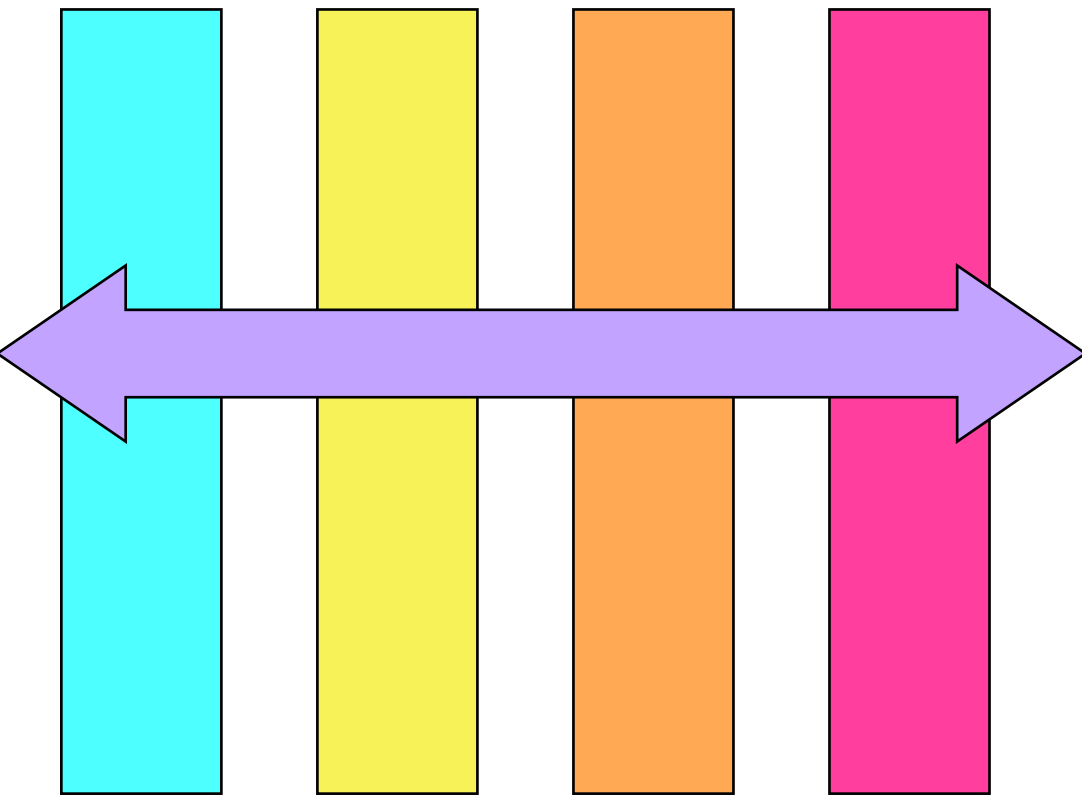
**Because it's hard to make the systems they use interact with each other**

# Symptoms
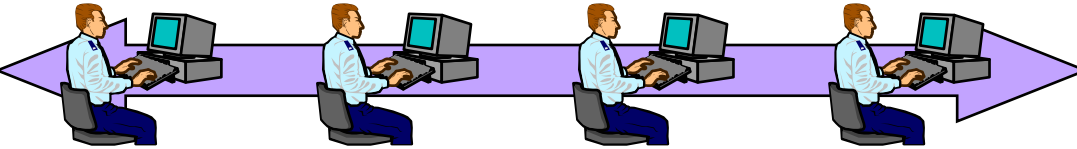
- **Hard to connect separate C2 systems**
  - **Different infrastructures**
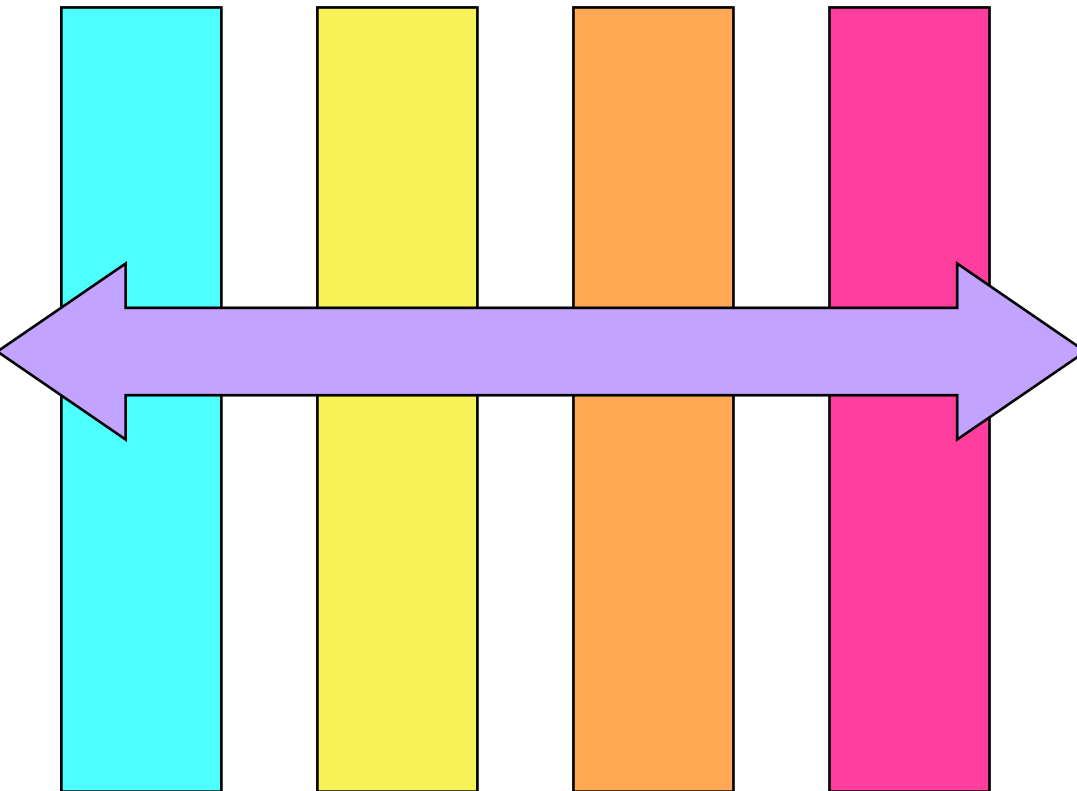
- **Hard to make systems exchange C2 information**
  - **Shared semantics are difficult to arrange**

- **Hard to administer groups of C2 systems**
  - **Each system needs its own sysadmin staff**

- **Hard to manage change in C2 systems and functions**
  - **Inflexible interfaces**
  - **Rigid infrastructure**

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# The Result
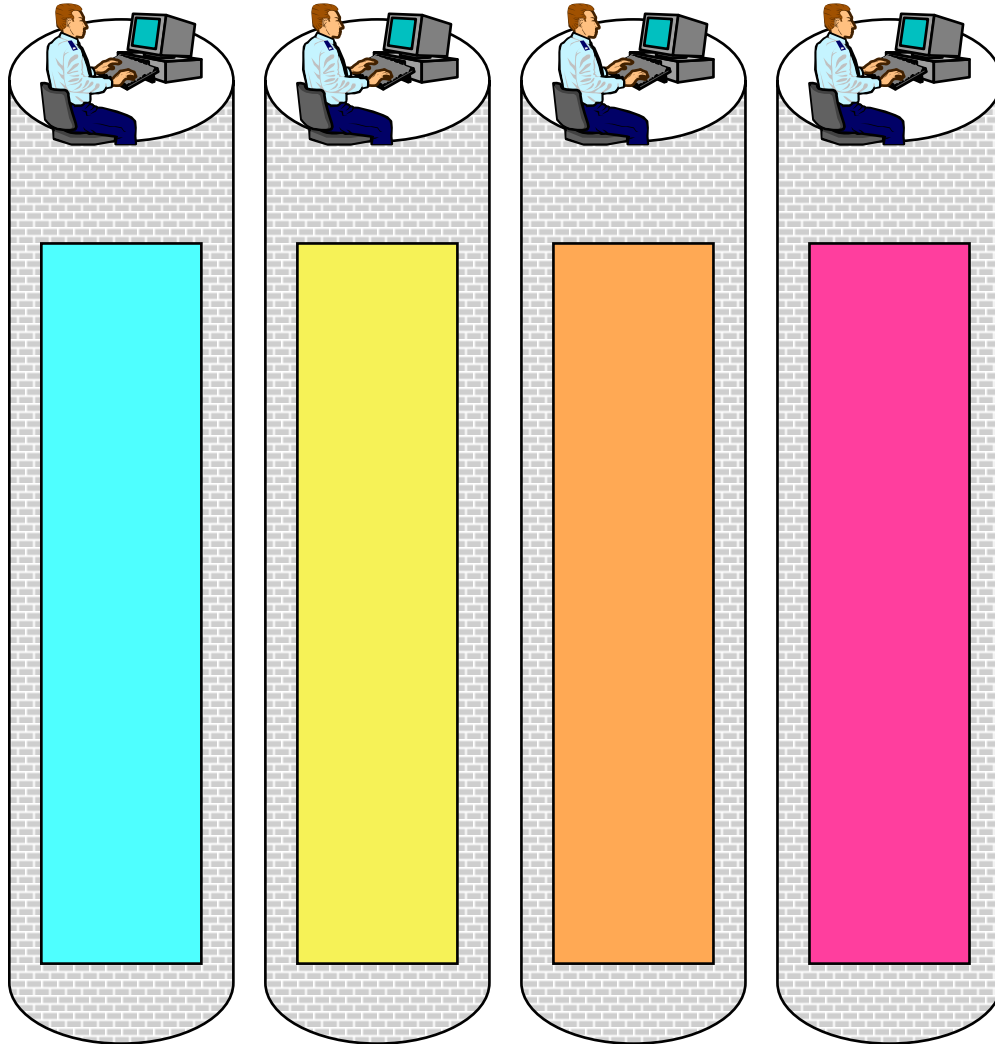


**Unhappy users**

**Important C2 capabilities
that we can't afford,
or build at any price**

**Inflexible, stovepipe systems**

**Co-evolution is impractical**

**Delay in achieving NCW**

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# The C2 ERA Solution

- **Change how we organize C2 enterprise acquisition**
  - **Manage programs and systems as components of *C2 Nodes***

- **Change how we build the individual C2 applications**
  - **Don't build separate infrastructure for each system**
  - **Deliver applications that share a *C2 Node Platform* and a *Common Integrated Infrastructure***

Two different changes…
both built around the same *C2 Node* concept

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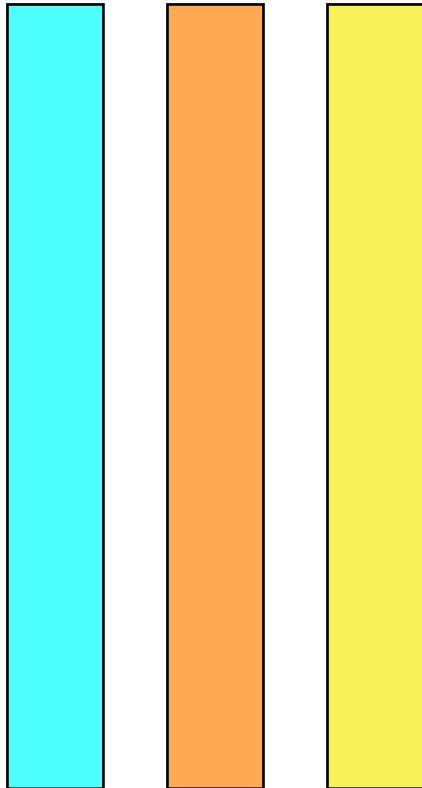
# First Change: How We Organize Acquisition



**Begin with users that must cooperate closely**

**Program offices build the applications that those users need**

**C2 Node Manager ensures that those applications are seamlessly integrated**

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# First Change: How We Organize Acquisition

**Begin with users that must cooperate closely**

C2 Node
(Weapon System)
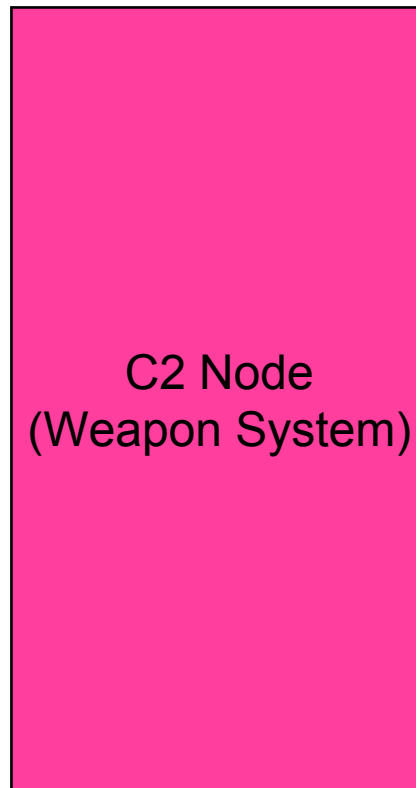
**Program offices build the applications that those users need**

**C2 Node Manager ensures that those applications are seamlessly integrated**

**And delivers integrated applications as a cohesive C2 weapon system**

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# First Change: How We Organize Acquisition
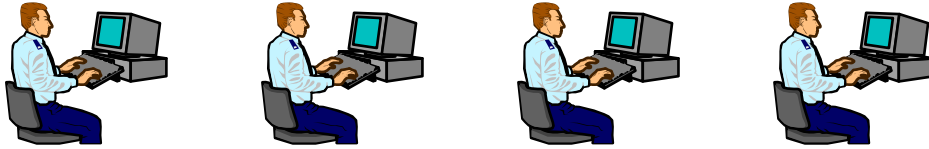
**Repeat for each distinct *C2 Node User Community* and each *C2 Node Capability***
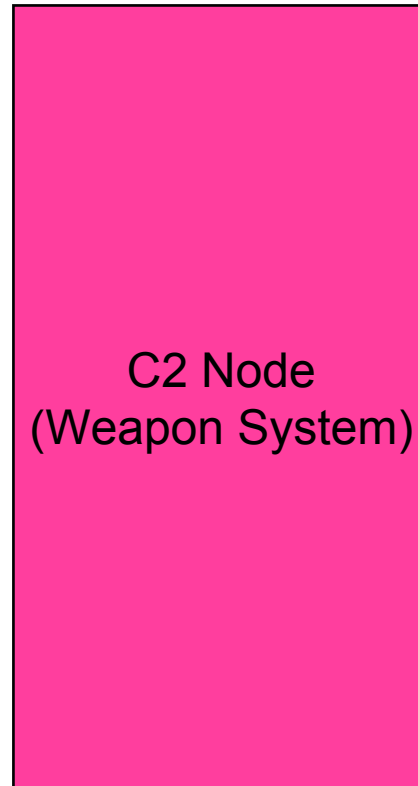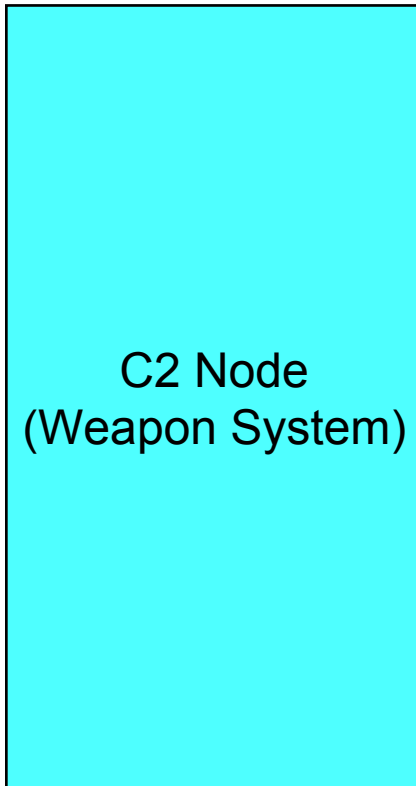
**Operational concerns dominate the selection of C2 Node boundaries...**

**But technical concerns can't be ignored – because you must be able to *build* the "weapon system" you *want***

C2 Node
(Weapon System)

C2 Node
(Weapon System)

Result: *Many* fewer C2 Nodes… better, but still not good enough

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# Today's Enterprise Integration Problem



**Capability 1** — ip ... ip

**Capability 2** — ip ... ip

**Capability 3** — ip ... ip

**Capability n** — ip ... ip

System 1

System m

Operational/Domain Focused

Systems/Technology Focused

10s of Capabilities (n)
1000s of Systems (m)
10,000s (n*m) of Integrati
Points

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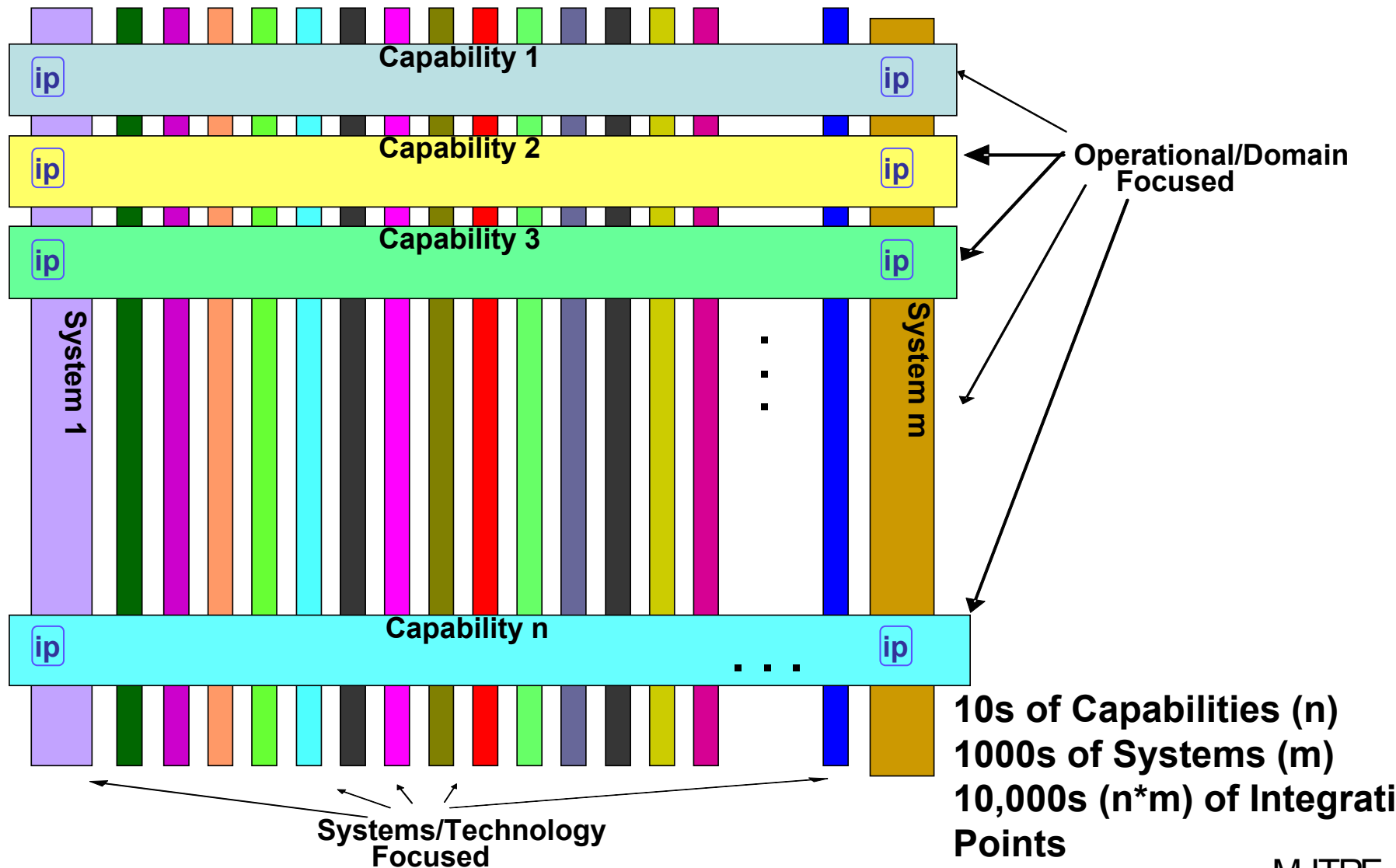
# C2 Node Impact on Enterprise Integration

**Enterprise Integration Problem**

Operational/Domain Focused

10s of Capabilities (n)
10s of Nodes (k)
100s (n*k) of Integration Points

Capability
Capability 2
Capability 3
Capability n

Node 1
Node 2
Node 3
Node k

ip

Systems/Business Focused

**+**

**Per Node Integration Problem**

10s of Capabilities (n)
10s of Systems (k)
100s (n*k) of Integration Points

Operational/Domain Focused

Capability 1
Capability 1
Capability 1
Capability 2
Capability 3
Capability n
Capability n

System 1
System 2
System 3
System k

ip

Systems/Business Focused

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# C2 Nodes

- **C2 Node:** *A set of materiel and non-materiel solutions that is managed as a weapon system[and provides warfighting capability at a specific location or set of locations.*

- **C2 Nodes are defined as strategically selected integration points to implement cross-mission and cross-capability integration**

- **Well chosen C2 Nodes will:**
  - Display <u>operational cohesion</u>:  Have users who need to collaborate closely to perform their missions
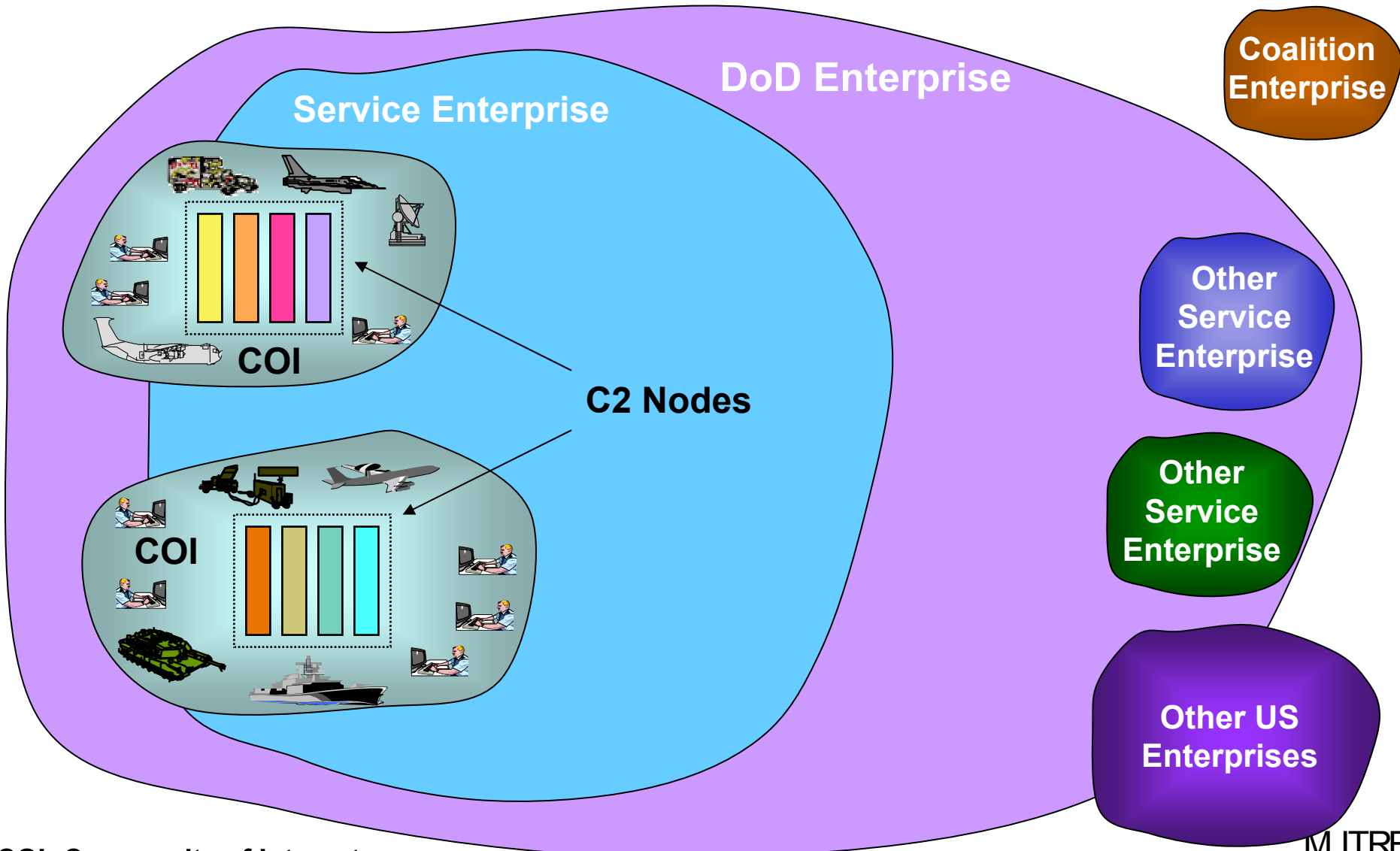  - Display <u>implementation cohesion</u>: Collect and integrate mission applications which must work together seamlessly to support the users
  - Display <u>infrastructure cohesion</u>: Collect mission applications which can be implemented using the same "C2 Node Platform" infrastructure

# Users and Systems Collected Into C2 Nodes



DoD Enterprise

Service Enterprise

COI

COI

C2 Nodes

Coalition Enterprise

Other Service Enterprise

Other Service Enterprise

Other US Enterprises

**COI: Community of Interest**

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# Second Change: How We Build
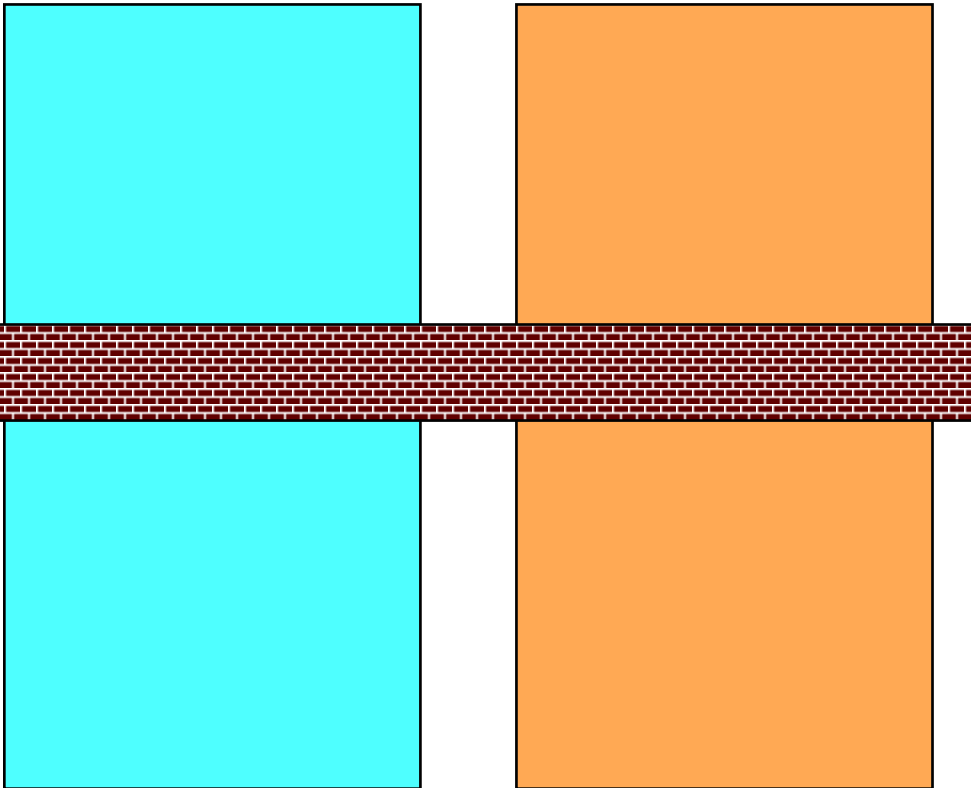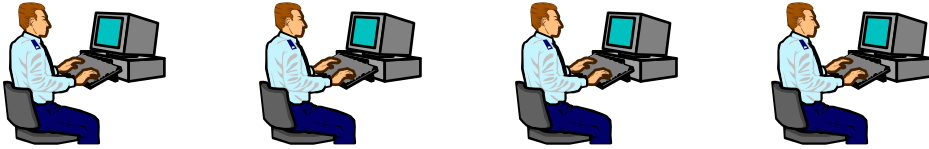
**Most program offices build mission applications**

**Applications and infrastructure are CLEARLY SEPARATED…**
– **Apps use infrastructure**
– **Ideally nobody builds both**

**A few program offices build infrastructure**

# Second Change: How We Build
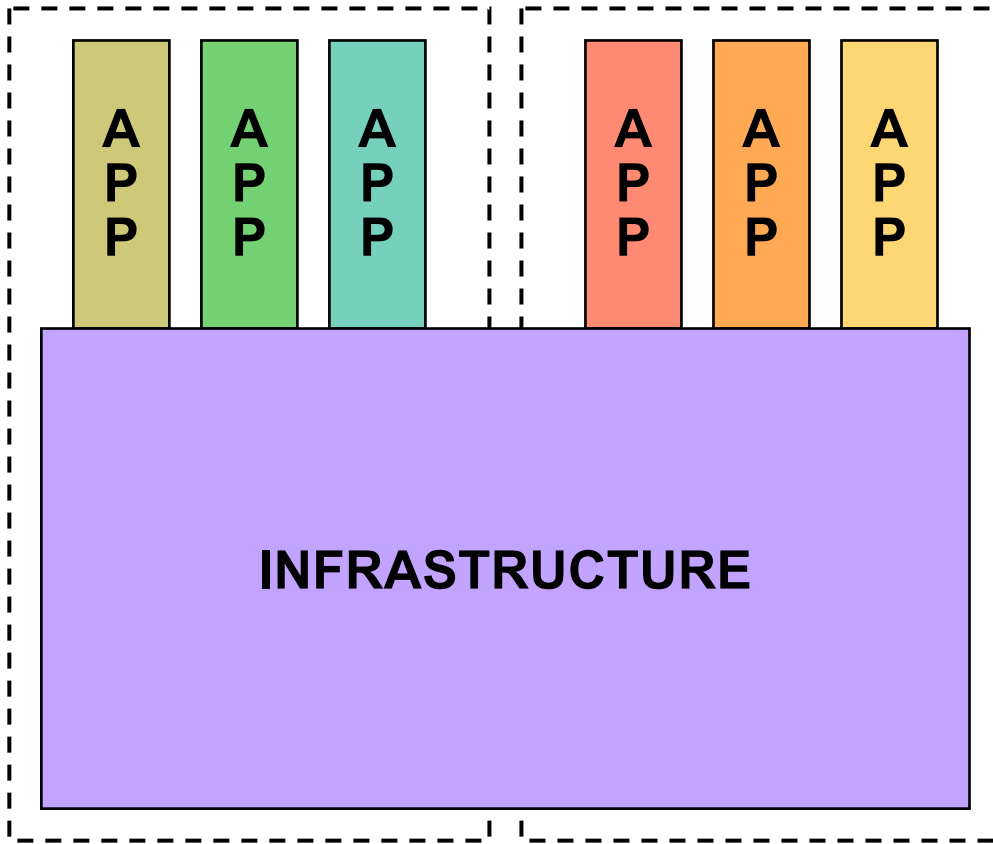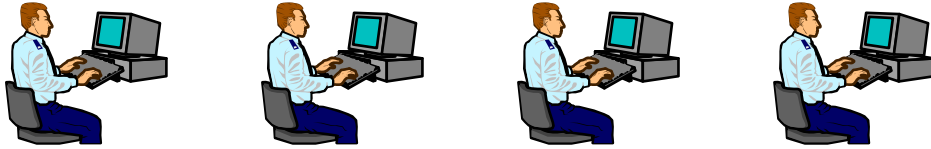


C2 Node      C2 Node

**INFRASTRUCTURE**

- **Programs build mission applications to satisfy user requirements**

- **Those applications must use the infrastructure specified, built, and operated by somebody else**

- **We can't build a single infrastructure that does everything for everyone, so...**

# Second Change: How We Build
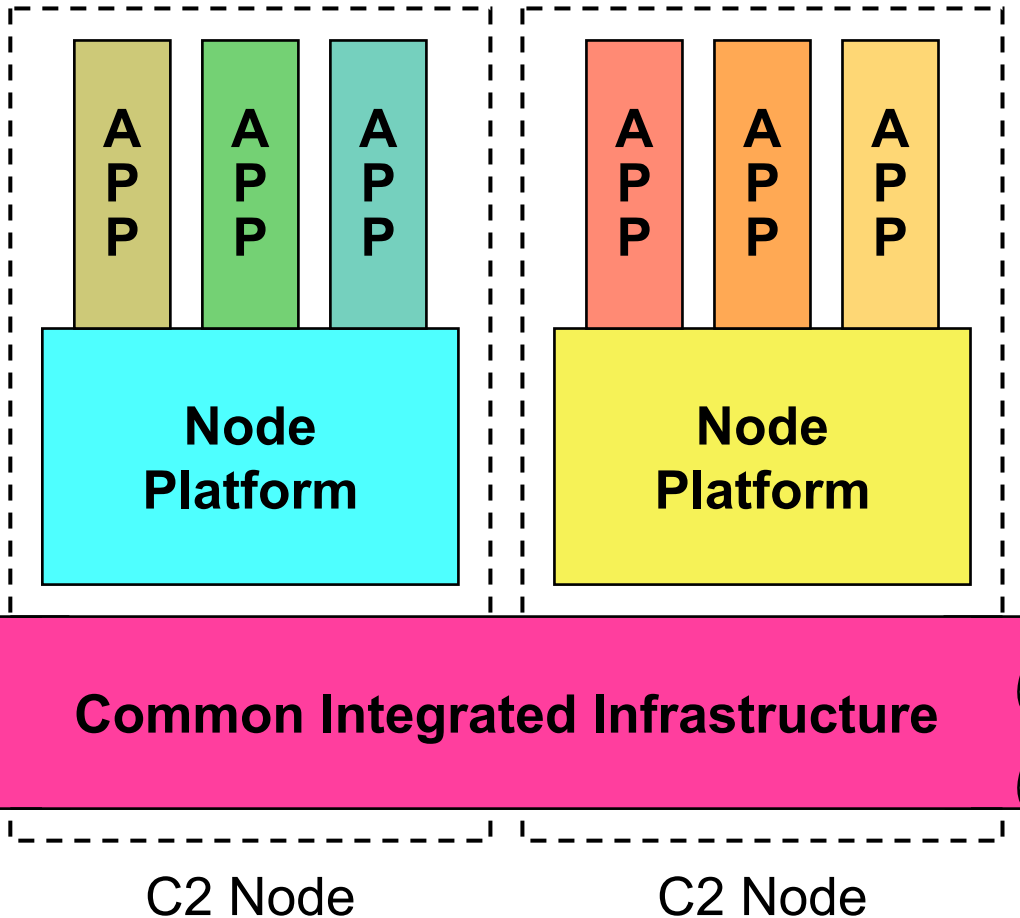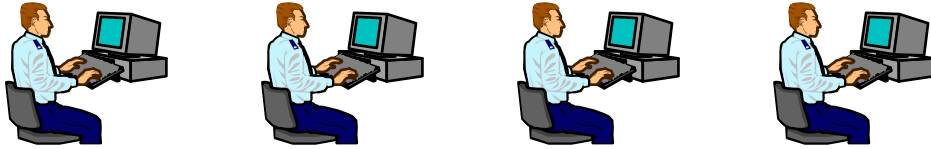


- **We split the infrastructure into two parts**

- **One part is different for each node**
  - **The C2 Node Platform is chosen by each Node Manager**

- **One part is the same for the entire C2 Enterprise**
  - **The Common Integrated Infrastructure is managed "like a node"**

- **The C2 Enterprise Reference Architecture describes the services in each part**

**APP** **APP** **APP**

**Node Platform**

**APP** **APP** **APP**

**Node Platform**

**Common Integrated Infrastructure**

C2 Node          C2 Node

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# Information Technology Overview
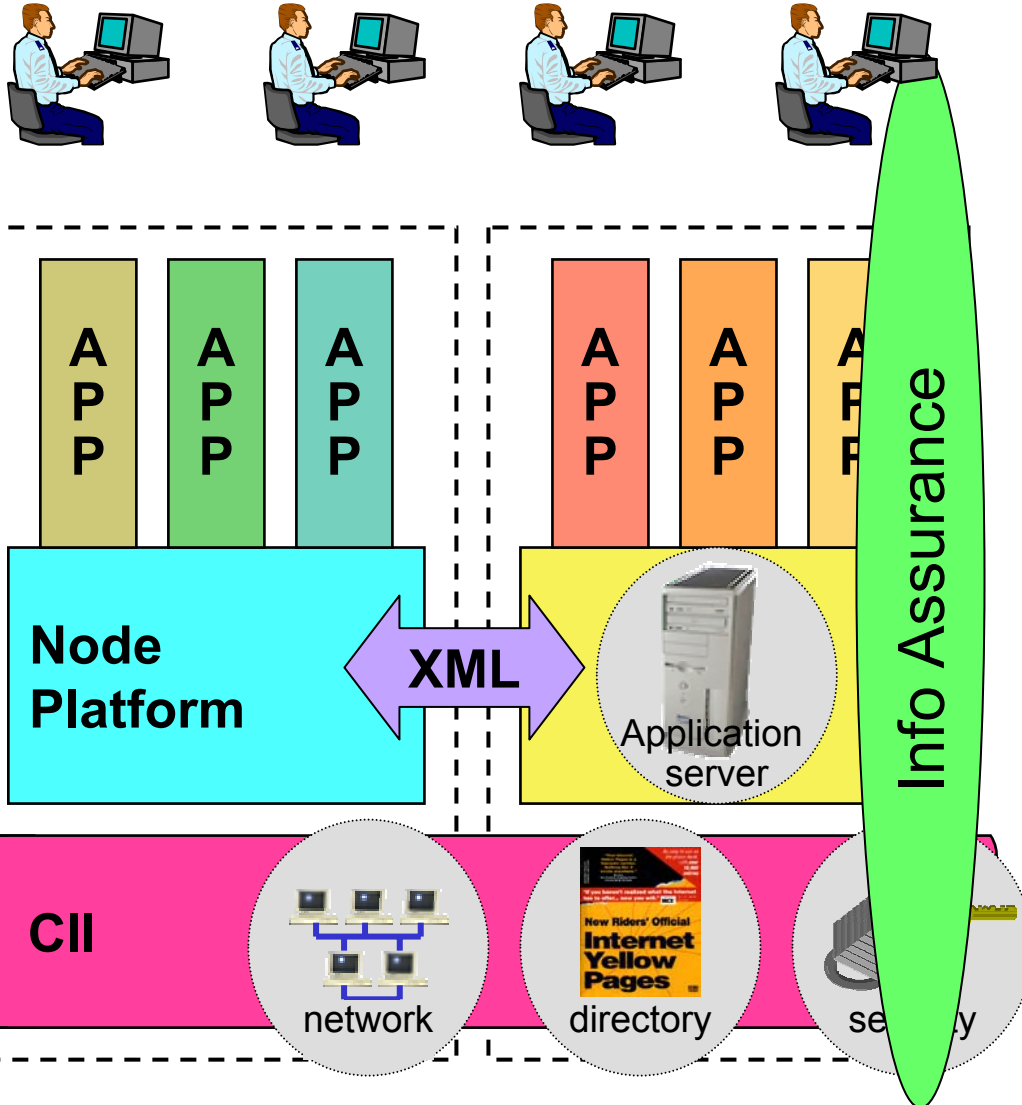


- **Global Grid – seamless, enterprise network**

- **Enterprise directory of people, services, etc.**

- **Component frameworks – a way to build applications**

- **XML Web Services – how C2 Nodes interact**

- **Enterprise info assurance services**

- **Info Assurance constraints across the architecture**

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# Why Divide The Infrastructure?
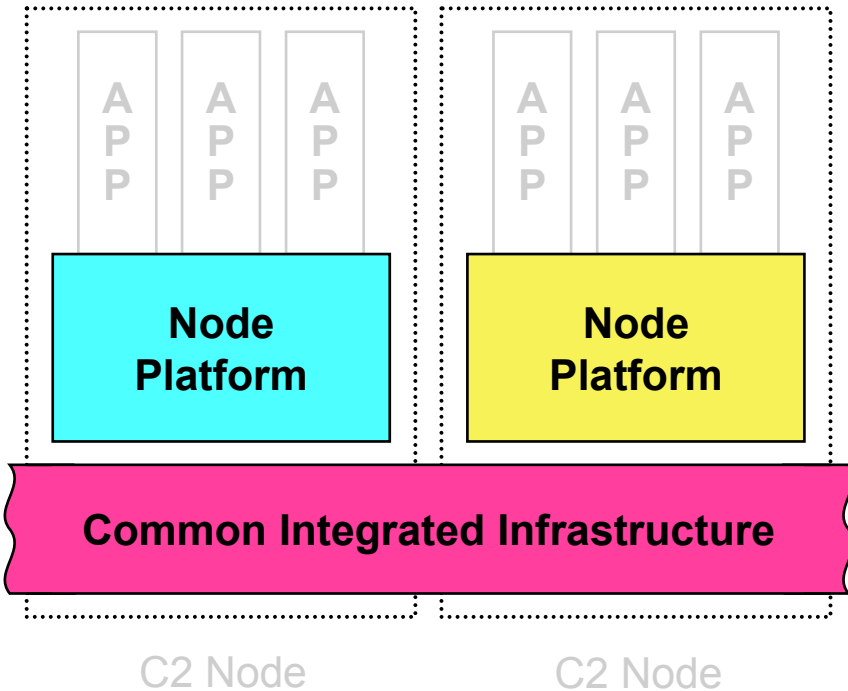


- **Why have Node Platforms? Why isn't everything in the CII?**
  - **Dependencies between nodes**
  - **Hard to change and evolve**

- **Why have the CII? Why isn't everything in Nodes?**
  - **Some things *must* be the same**

- **What makes a service belong in the enterprise-level CII?**
  - **Enterprise essential**
  - **Enterprise control**
  - **Enterprise scale**
  - **Enterprise content or connectivity**

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# CII Example: Domain Name Service (DNS)

`www.acc.af.mil`

**Service Request from Anywhere**

Q: What is the IP address of `www.acc.af.mil` **?**

A: 131.6.12.199

DNS

**Common Integrated Infrastructure**

## DNS belongs in the CII because:

- **DNS is a service**

- **DNS is essential**

- **Nobody builds their own DNS**

- **DNS is available everywhere**

- **It is the same DNS everywhere**

- **The DNS content is created by many people**

- **All this works because the rules for connecting DNS servers and for creating DNS content are the same for the whole enterprise.**

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# DNS Is More Than Software

`www.acc.af.mil`

**Service Request from Anywhere**

**Q: What is the IP address of `www.acc.af.mil` ?**

**[no response]**

DNS software

DNS

**Common Integrated Infrastructure**

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# DNS Is More Than Software + Hardware

`www.acc.af.mil`

**Service Request from Anywhere**

**Q: What is the IP address of `www.acc.af.mil` ?**

**A: unknown**

DNS software *and*

**DNS**

**Common Integrated Infrastructure**

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# DNS Is People, Process, and Technology

`www.acc.af.mil`

DNS software *and*
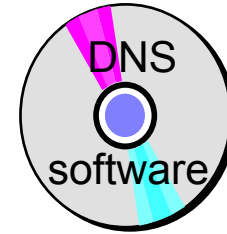
*and*

**Service Request from Anywhere**

**Q: What is the IP address of `www.acc.af.mil`?**

**A: 131.6.12.199**

I control the .mil domain

I control af.mil

I control acc.af.mil
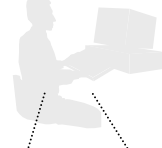
**DNS**

Let www.acc.af.mil = 131.6.12.199

**Common Integrated Infrastructure**

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# Result of the Two Changes
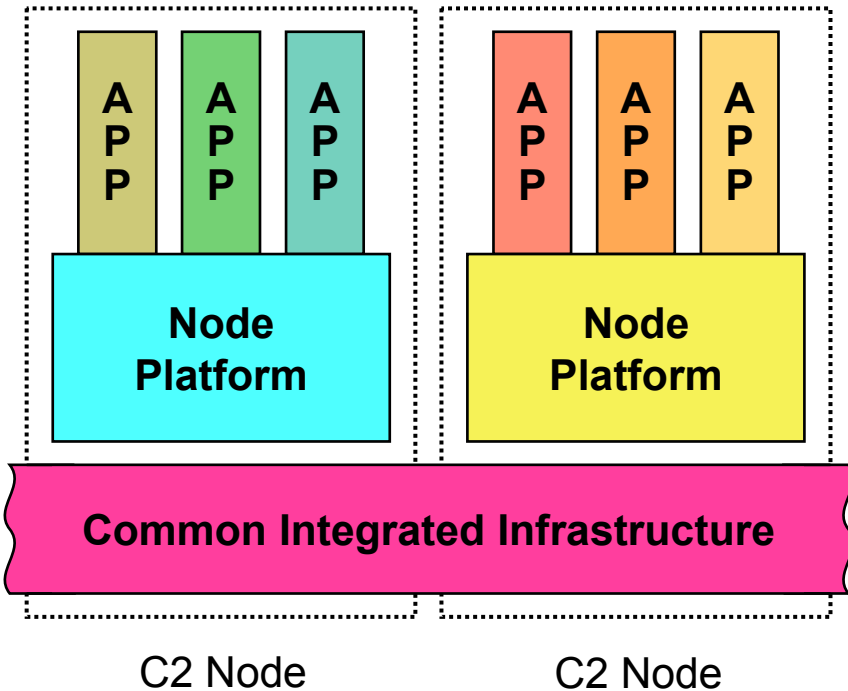


**C2 Node**    **C2 Node**

- **Gather together (within each C2 Node) applications, which formerly were separate and independent**

- **Separate each application from its infrastructure… things which formerly were combined together**

- **Improved cohesion between things that should work together**

- **Reduced coupling between things that should change independently**

- **Better functionality and flexibility**

New technology supports these improvements

# C2ERA and GES / NCES

APP APP APP | APP APP APP

Node Platform ← XML → Node Platform

**Common Integrated Infrastructure**

**Users**

**Dynamically Created COIs**

**Weapon Systems**

**Sensors**

**Finance**

**Intel**

**Community-of-Interest (COI) Capabilities**

**C2**

**Logistics**

**Personnel**

**Etc.**

**Levels of Services above core level**

**Comms**

**Backbone**

**ESM**    **Messaging**    **Mediation**    **Security/IA**    **User Asst**

**Discovery**    **Collaboration**    **Storage**    **App**

**Core Enterprise Services (CES)**

Global Information Grid (GIG) Enterprise Services (GES)

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# Summary

- **C2ERA makes two changes to C2 systems**
  - **Manage related applications as *C2 Nodes***
  - **Separate mission functionality from infrastructure**

- **Infrastructure separated into**
  - **Common Integrated Infrastructure (CII)
    Same for the whole enterprise**
  - **Node platforms – can be different for each C2 Node**

- **Consistent with new DoD approach**

- **Result: better functionality and flexibility**

- **Made feasible by new technology**

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