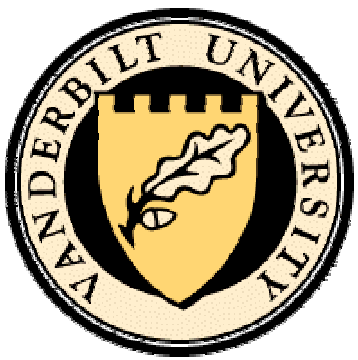
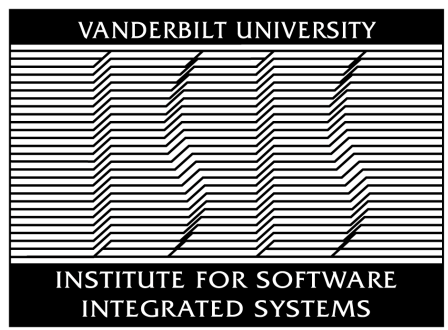
CoSMIC: An MDA Tool Suite for Distributed Real-time and Embedded Systems

Aniruddha Gokhale, Balachandran Natarajan, Jeff Parsons, K. Balasubramaniam, Tao Lu, Boris Kolpakov

{gokhale, bala, parsons, kitty, lu, boris}@isis.vanderbilt.edu
www.dre.vanderbilt.edu/cosmic

ISIS, Vanderbilt University
Nashville, TN 37203

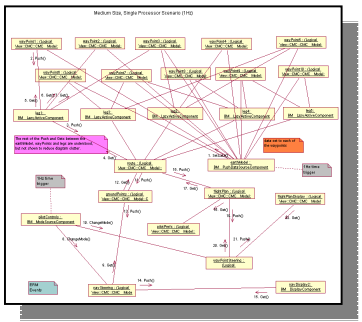


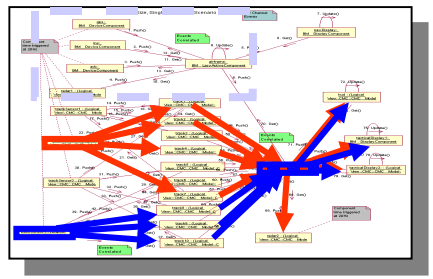


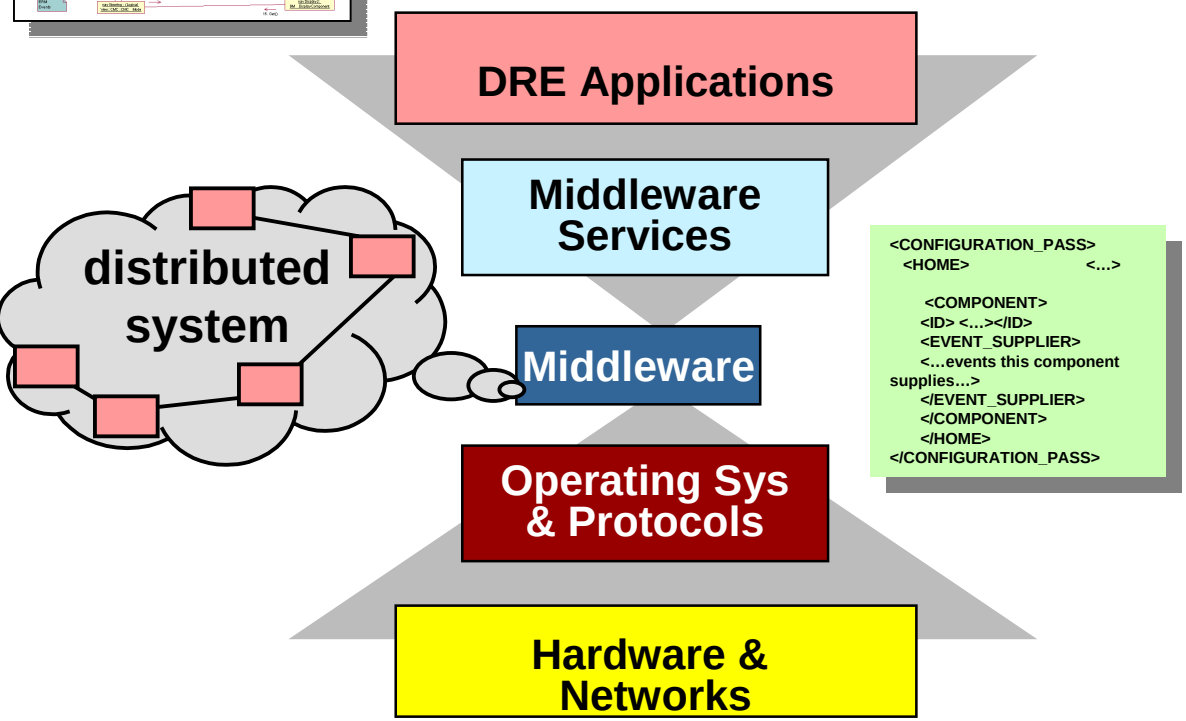
Work supported by AFRL contract# F33615-03-C-4112
for DARPA PCES Program

Research Synopsis

Model Driven Approach for Distributed Real-time & Embedded Middleware








```
<CONFIGURATION_PASS>
  <HOME>                    <...>

    <COMPONENT>
    <ID> <...></ID>
    <EVENT_SUPPLIER>
    <...events this component
supplies...>
    </EVENT_SUPPLIER>
    </COMPONENT>
    </HOME>
</CONFIGURATION_PASS>
```

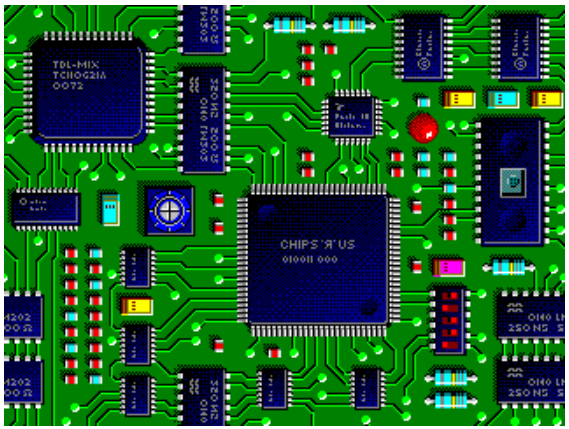
Develop, validate, & help to standardize technologies that:

(1) Model
(2) Analyze
(3) Synthesize &
(4) Provision

multiple layers of middleware for distributed real-time and embedded (DRE) systems that require ***simultaneous control*** of ***multiple quality of service properties end-to-end***

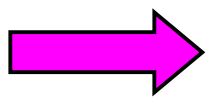
Distributed Real-time & Embedded Systems

The Past



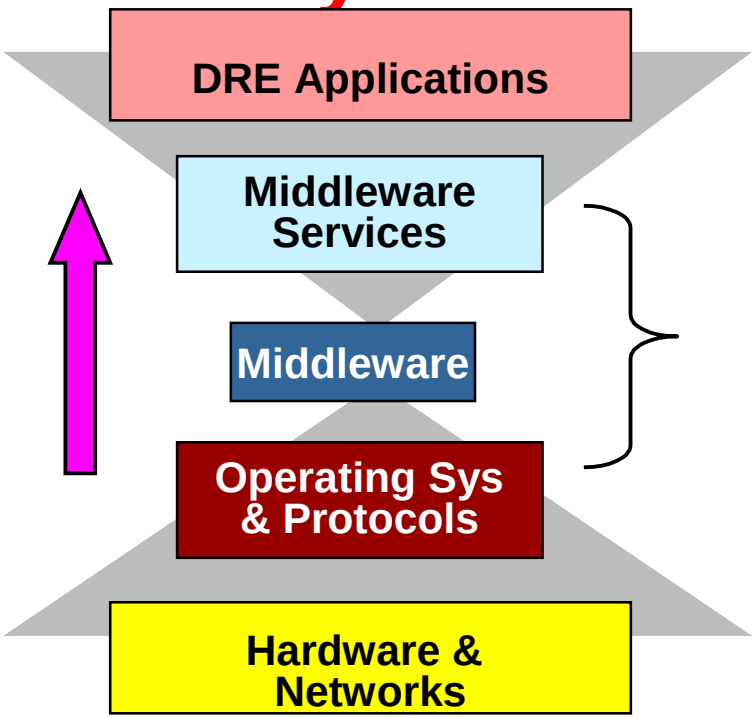
The Future

- Stringent simultaneous quality of service (QoS) demands
- Part of larger systems
- Resource constrained



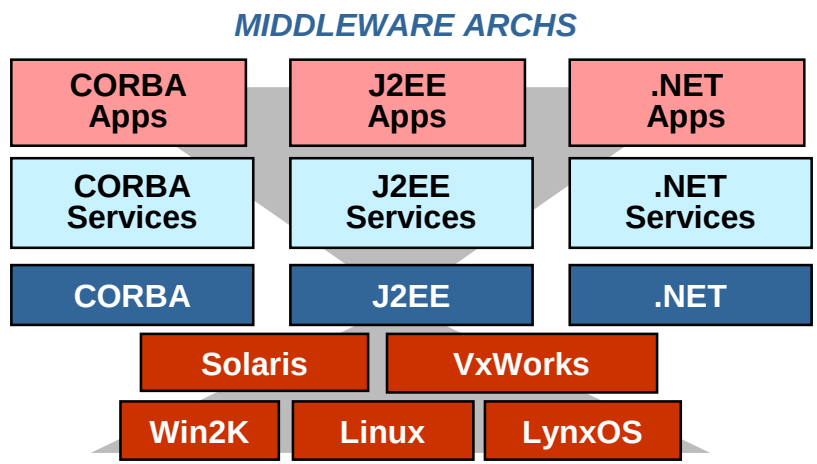
- Network-centric & large-scale
- Dynamic context
- Stringent simultaneous quality of service (QoS) demands
- Part of larger systems
- Resource constrained

DRE Systems: The Challenges Ahead (1/2)



- There is a limit to how much application functionality can be factored into broadly reusable COTS middleware
- Middleware has become extremely complicated to use, configure, & provision statically & dynamically

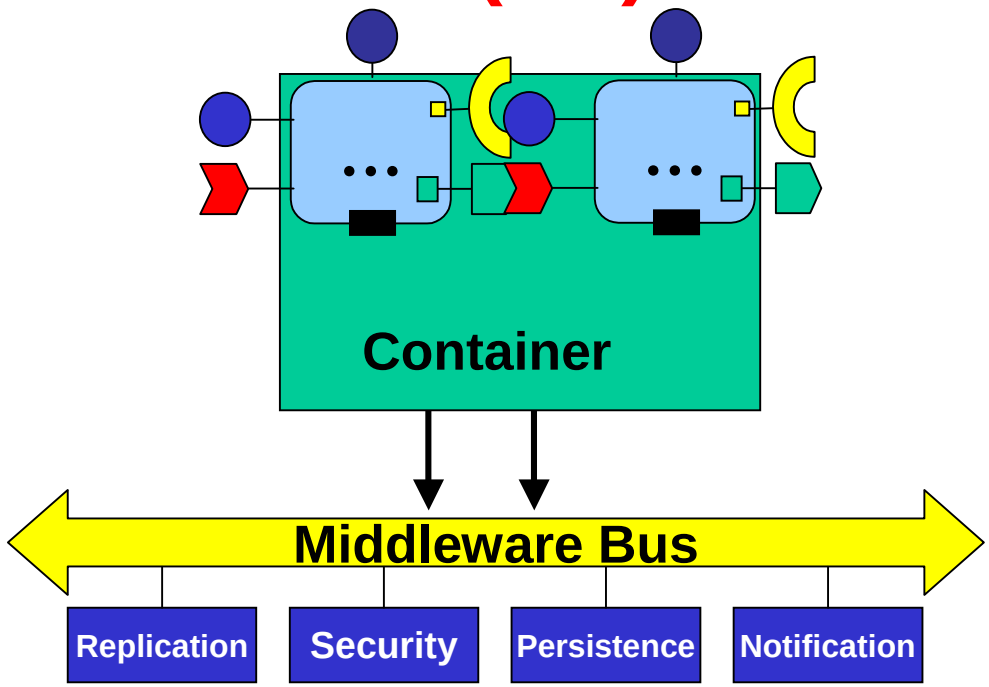
- There are now multiple middleware technologies to choose from



DRE Systems Challenges: Emergence of Component Middleware (2/2)

Context

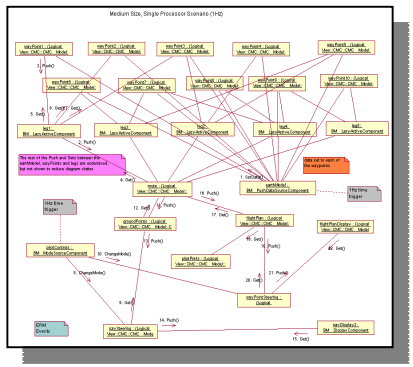
- Component middleware gaining importance (CCM, J2EE, .NET)
- Components encapsulate application core logic
- Components possess
  - Event sinks & sources
  - Connection points e.g., receptacles
  - Interfaces e.g., facets
  - attributes
- Containers provide execution environment for components with common operating requirements
- Containers communicate via a middleware bus

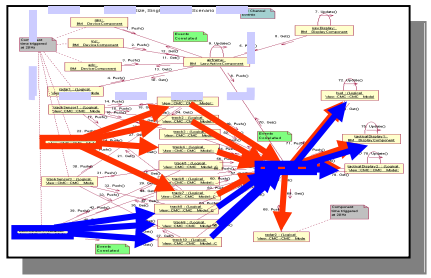


Challenges

- Accidental complexities configuring the middleware
- Accidental complexities deploying semantically compatible components

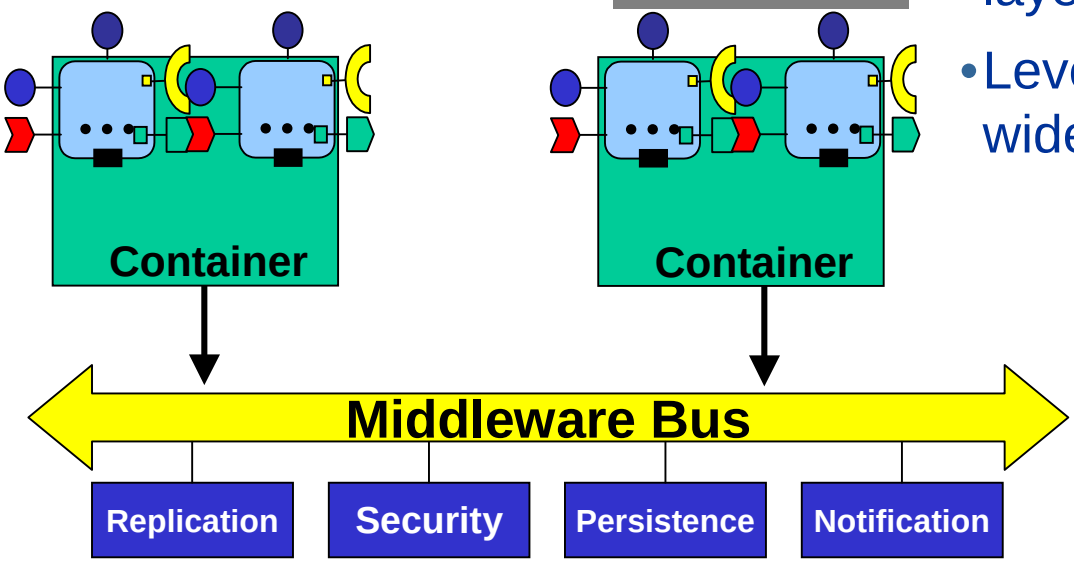
Our Solution: *Model-Driven* Middleware for DRE Systems





```
<CONFIGURATION_PASS>
  <HOME>                    <...>

     <COMPONENT>
    <ID> <...></ID>
    <EVENT_SUPPLIER>
    <...events this component
supplies...>
    </EVENT_SUPPLIER>
    </COMPONENT>
    </HOME>
</CONFIGURATION_PASS>
```



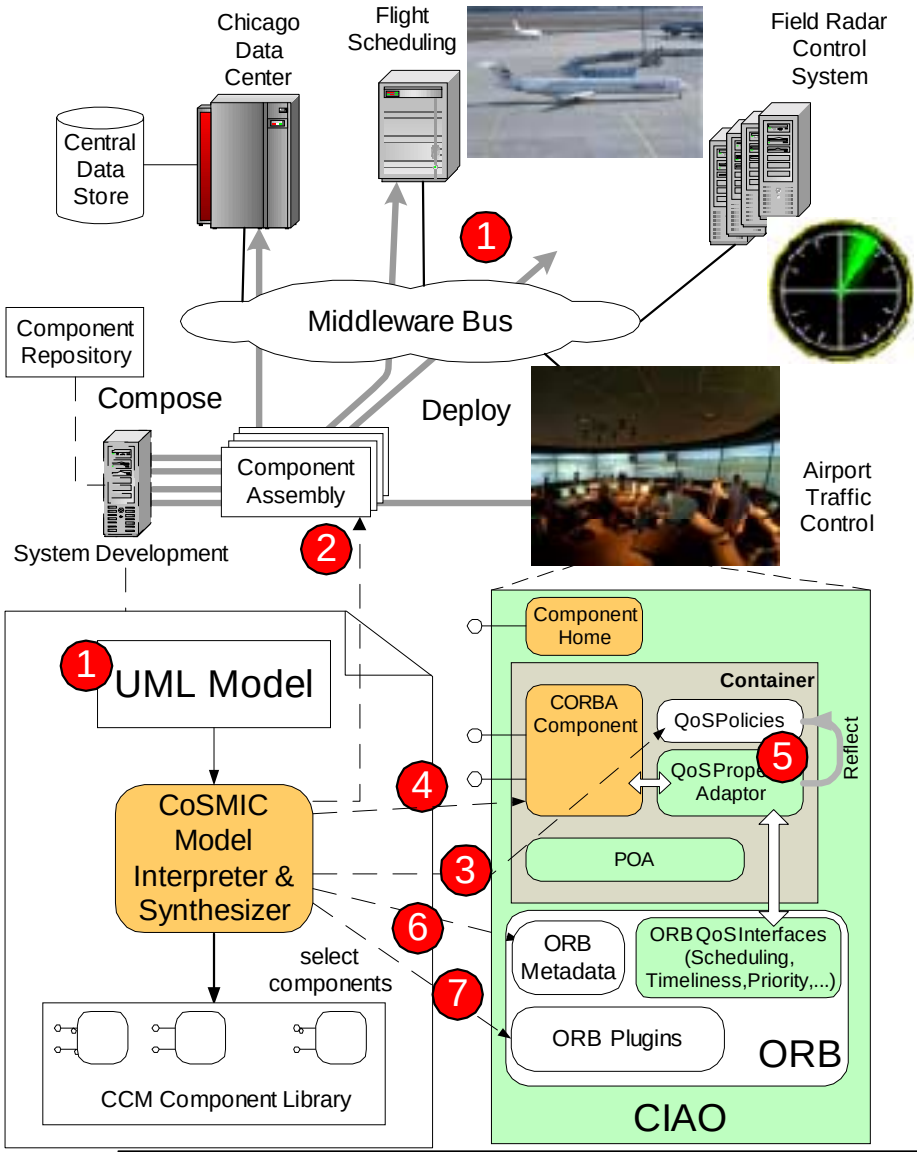
Key Benefits

- Preserves DRE application functional & systemic QoS properties as high level models
- Domain-specific languages & analysis/synthesis tools transform models to customize underlying multi-layered middleware platforms
- Leverages & shapes standards for wider applicability

Related Work:

- MIC, Vanderbilt (Sztipanovits, Karsai, et al)
- Ptolemy, UC Berkeley (Lee et al)
- Cadena, KSU (John Hatcliff et al)
- Quality Connector, LMCO (Joe Cross et. al)

MDA-Component Middleware Integration

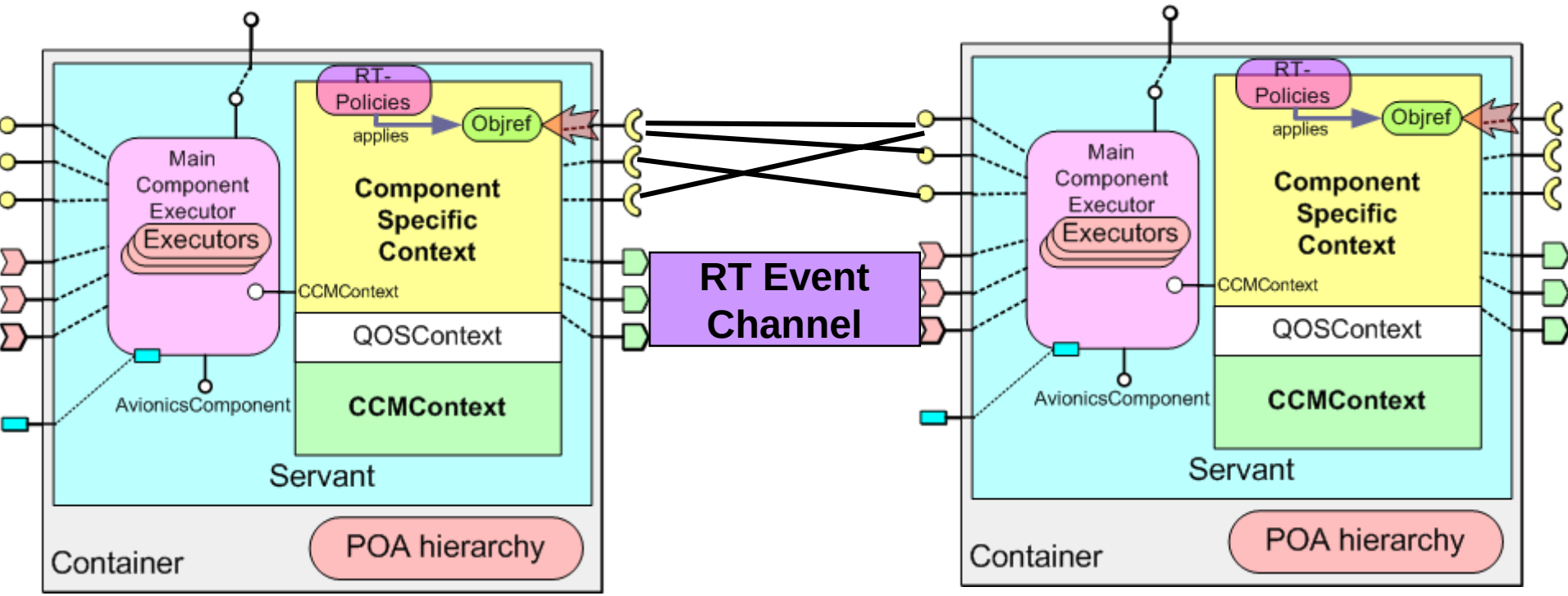


- Our tool suite is called CoSMIC
  - CoSMIC = Component Synthesis using Model Integrated Computing

Goals

- Configuring and deploying application services end-to-end
- Composing components into component servers
- Configuring application component containers
- Synthesizing application component implementations
- Synthesizing dynamic QoS provisioning and adaptation logic
- Synthesizing middleware-specific configurations
- Synthesizing middleware implementations

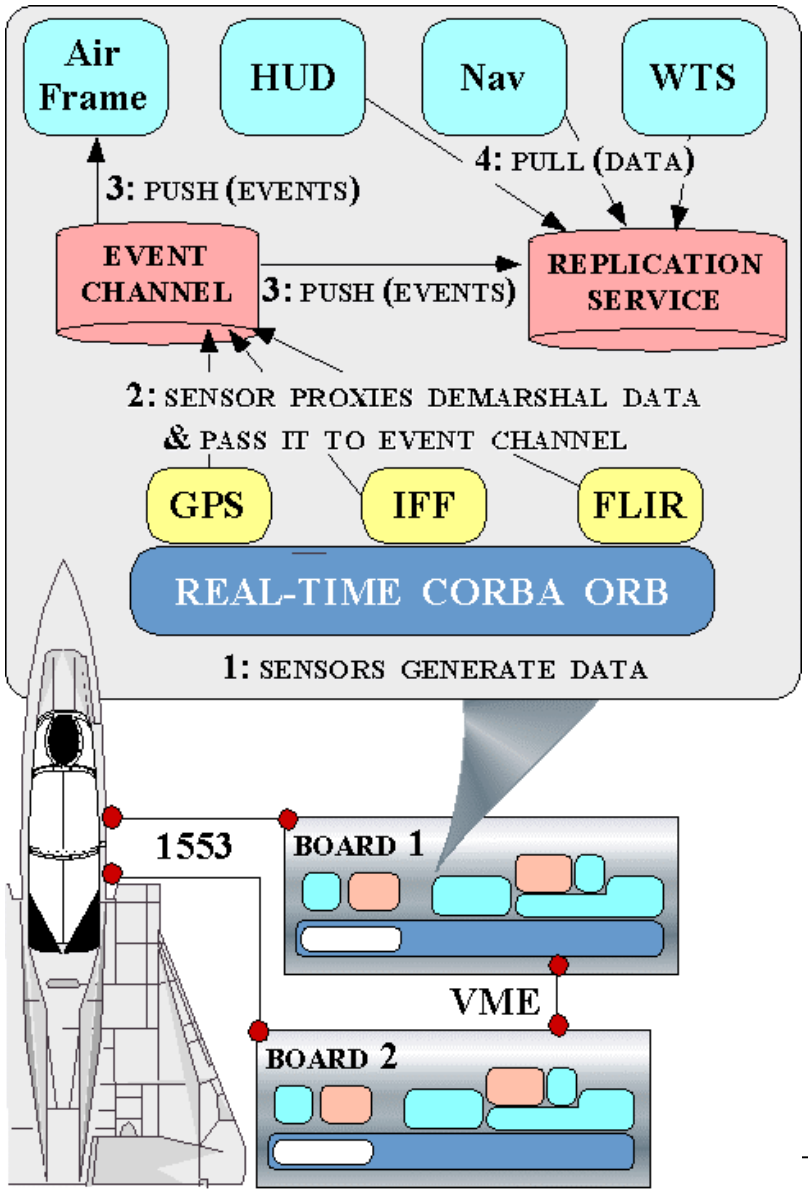
Current Target Middleware: CIAO CORBA Component Model



Focus on infrastructure support for composition of the following aspects

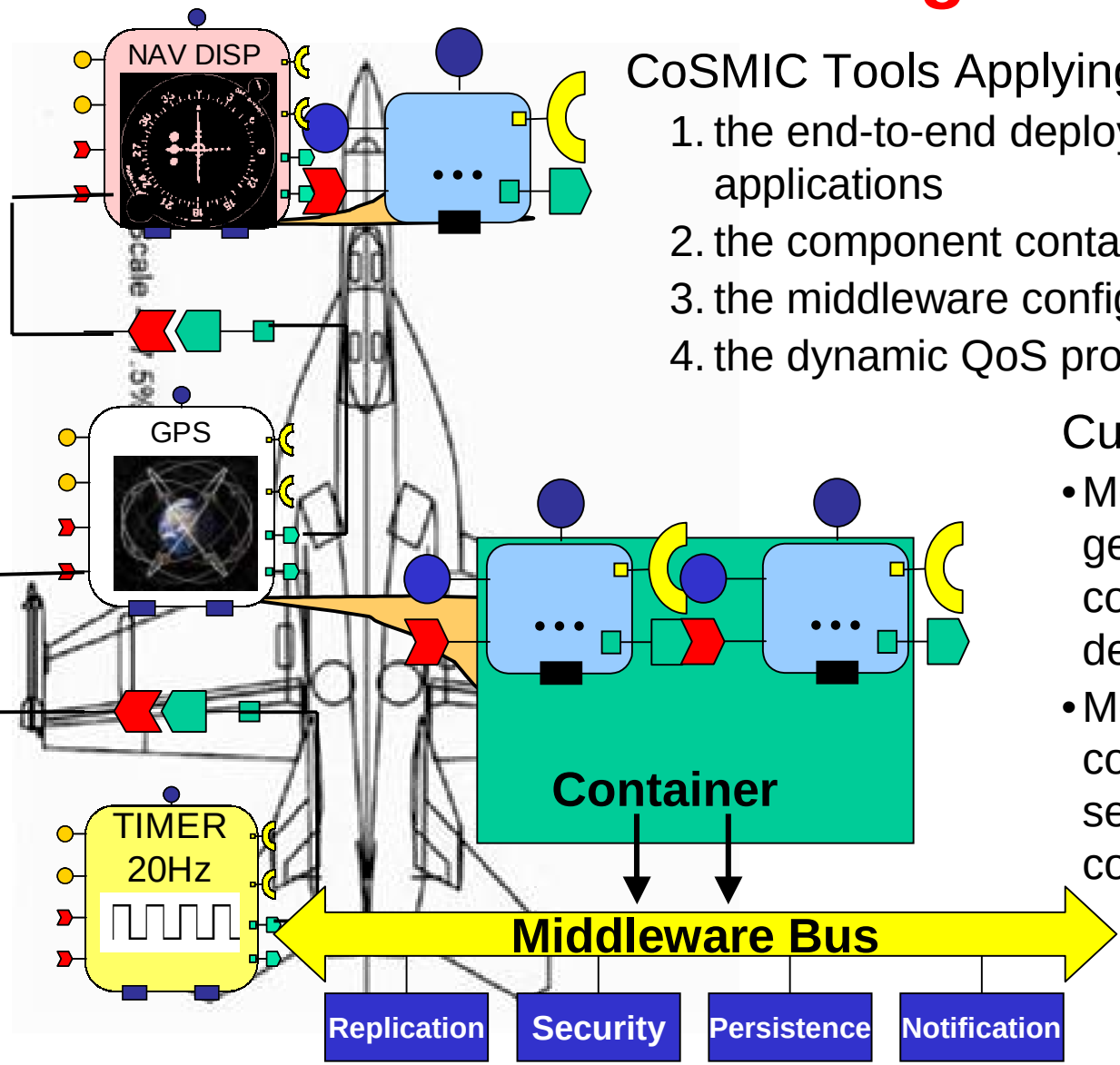
- **CIDL compiler to synthesize component descriptor metadata & stubs/skeletons**
- **RT event channel integration with CIAO containers**
- **Assembly & deployment framework**
- **Collaboration with Washington University**

Boeing Bold Stroke: Current Target Domain



- Avionics Product Line Component Model
- DRE system with 3,000+ domain-specific software components, 3-5 million lines of C++ code
- 100+ developers
- Mission-control software for Boeing military aircraft, e.g., F-18 E/F, Harrier, UCAV
- Leverages the ACE+TAO middleware
- Used as Avionics Open Experimental Platform (OEP) for DARPA/IXO PCES & MoBIES programs
- Moving towards using CIAO CCM

Concluding Remarks



CoSMIC Tools Applying MDA to address

1. the end-to-end deployment aspect of DRE applications
2. the component container configuration aspect
3. the middleware configuration aspect
4. the dynamic QoS provisioning & adaptation aspect

Current Status:

- Modeling paradigm and generators developed for CCM component assembly & deployment
- Modeling paradigm and constraint checker to determine semantic compatibility of ORB configuration options

Downloading the Middleware & Tools

CIAO

- Beta and Stable release can be accessed from **http://www.dre.vanderbilt.edu/Download.html**

CoSMIC

- **http://www.dre.vanderbilt.edu/cosmic**