Techniques for Dynamic Swapping in the Lightweight CORBA Component Model

Jaiganesh Balasubramanian
jai@dre.vanderbilt.edu
www.dre.vanderbilt.edu/~jai

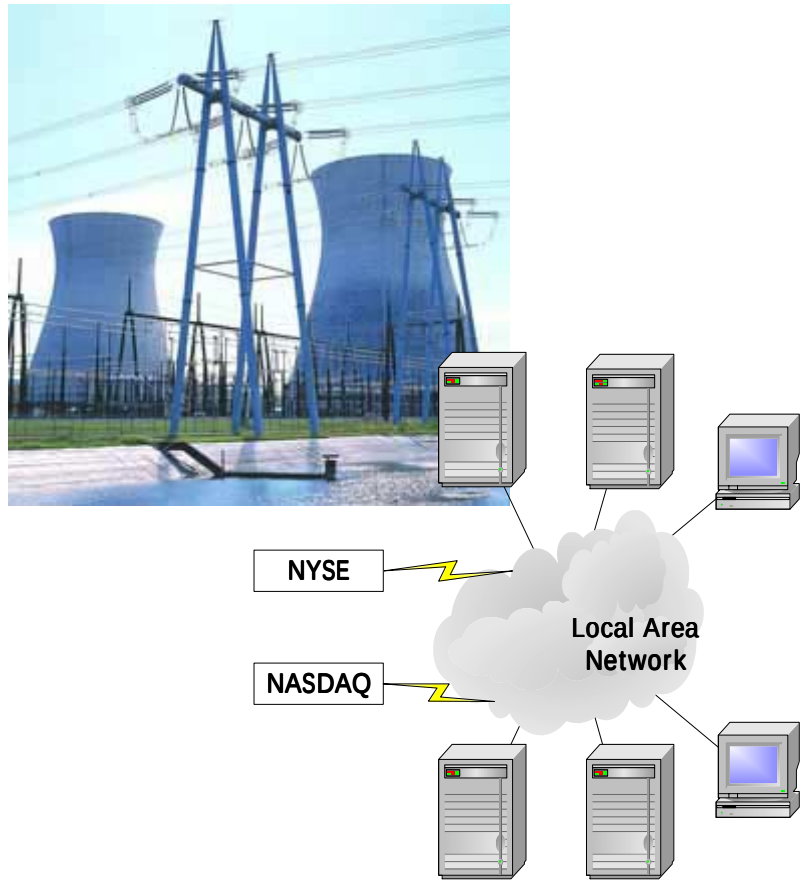
Dr. Aniruddha Gokhale
gokhale@dre.vanderbilt.edu
www.dre.vanderbilt.edu/~gokhale

Dr. Douglas C. Schmidt
schmidt@dre.vanderbilt.edu
www.dre.vanderbilt.edu/~schmidt

Institute for Software Integrated Systems
Vanderbilt University
Nashville, Tennessee

Motivation: Highly Dynamic Distributed Systems

- Heterogeneous environments
- Large number of bursty clients
- Stringent QoS requirements, e.g.:
  - 24x7 availability
  - Low latency & high throughput
- Examples
  - Online trading systems
  - Mission-critical systems for critical infrastructure
    - e.g., air transportation, power grid control

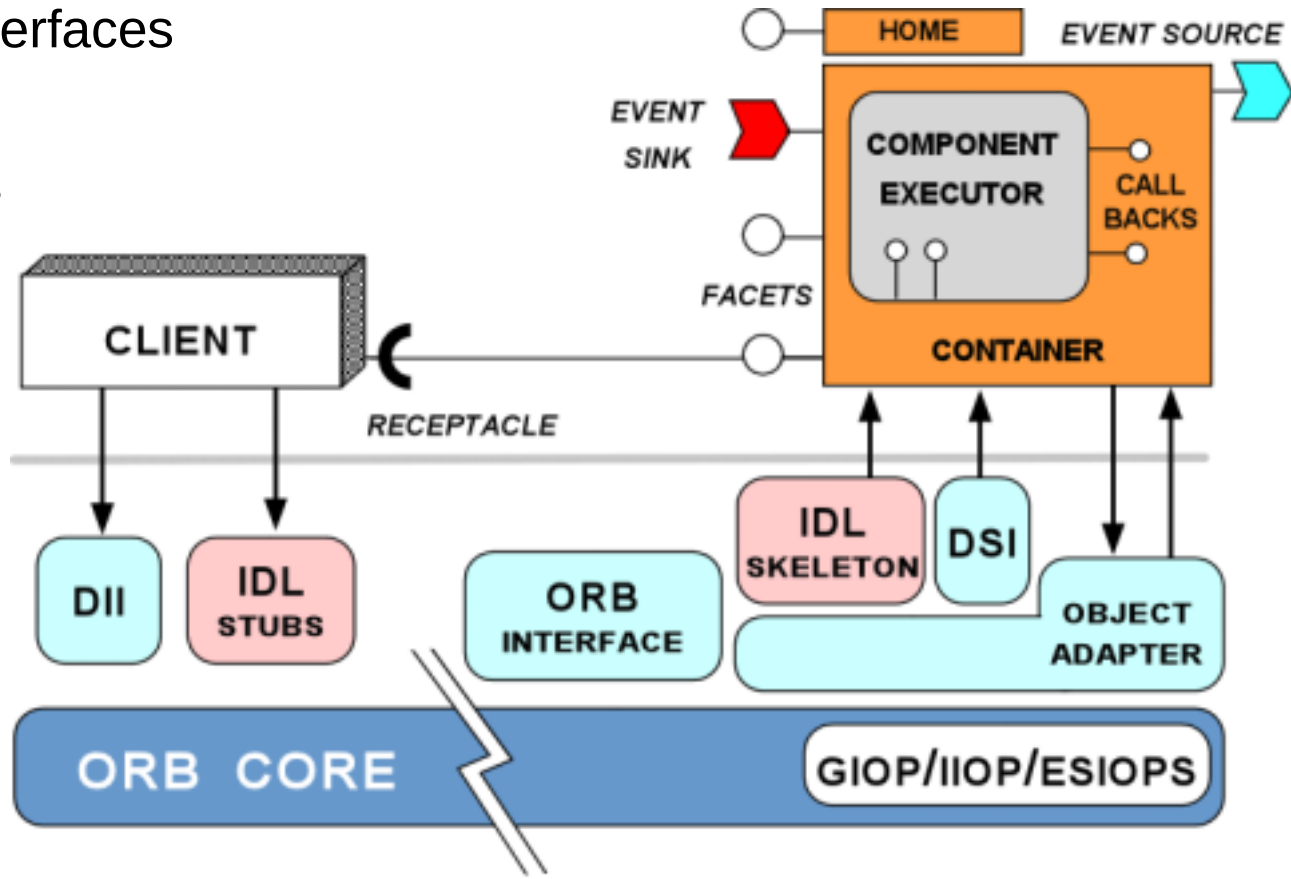


Our R&D goal is to assure the adaptability of these types of distributed systems

Component Middleware Distributed Systems

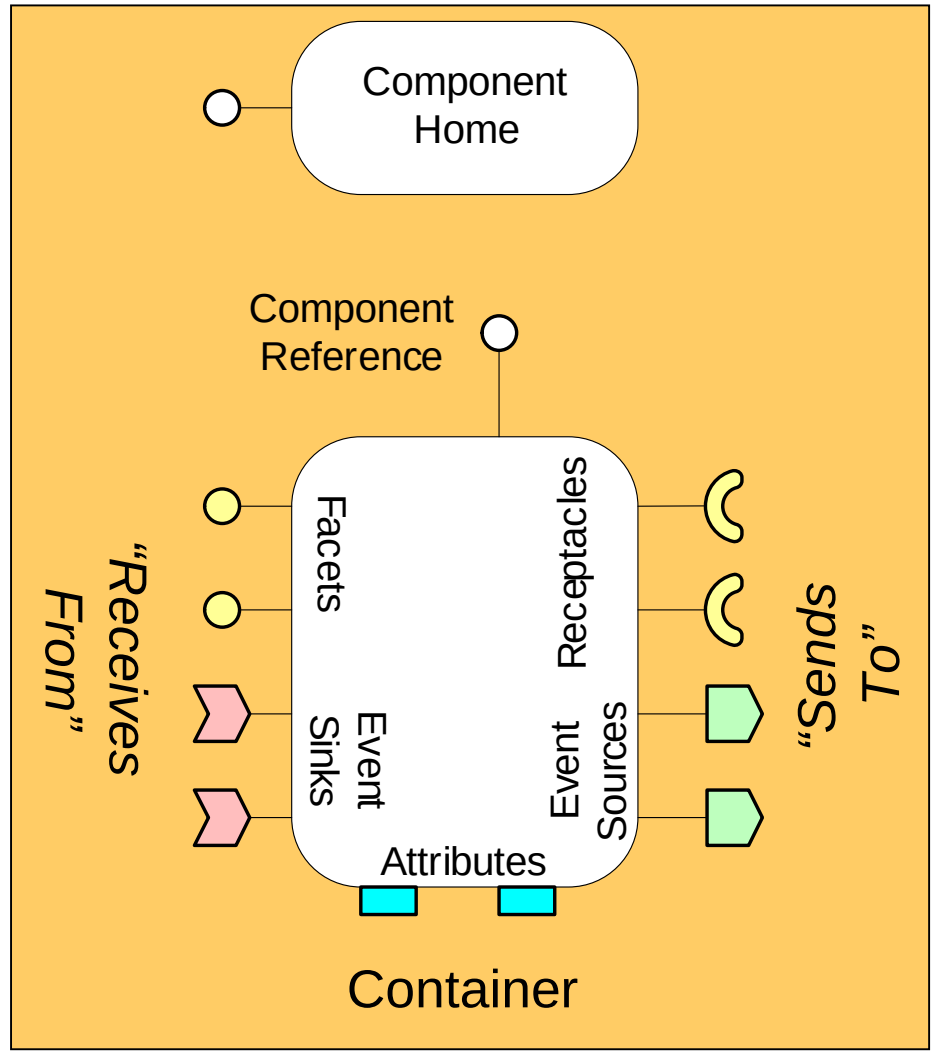
Component middleware capabilities:

- Creates a standard "virtual boundary" around application ***component*** implementations that interact only via well-defined interfaces
- Define standard ***container*** mechanisms needed to execute components in generic component servers
- Specify a reusable/ ***standard infrastructure*** needed to configure & deploy components throughout a distributed system



Overview of Lightweight CCM

- Many DRE CORBA applications can't use "enterprise" CCM due to constraints like limited processing overhead for performance-intensive applications
- CCM features supported by Lightweight CCM are:
  - All types of ports, i.e., Facets, Receptacles, Event sources and sinks and attributes.
  - Component homes.
  - Monolithic implementations.
  - Session components and containers.

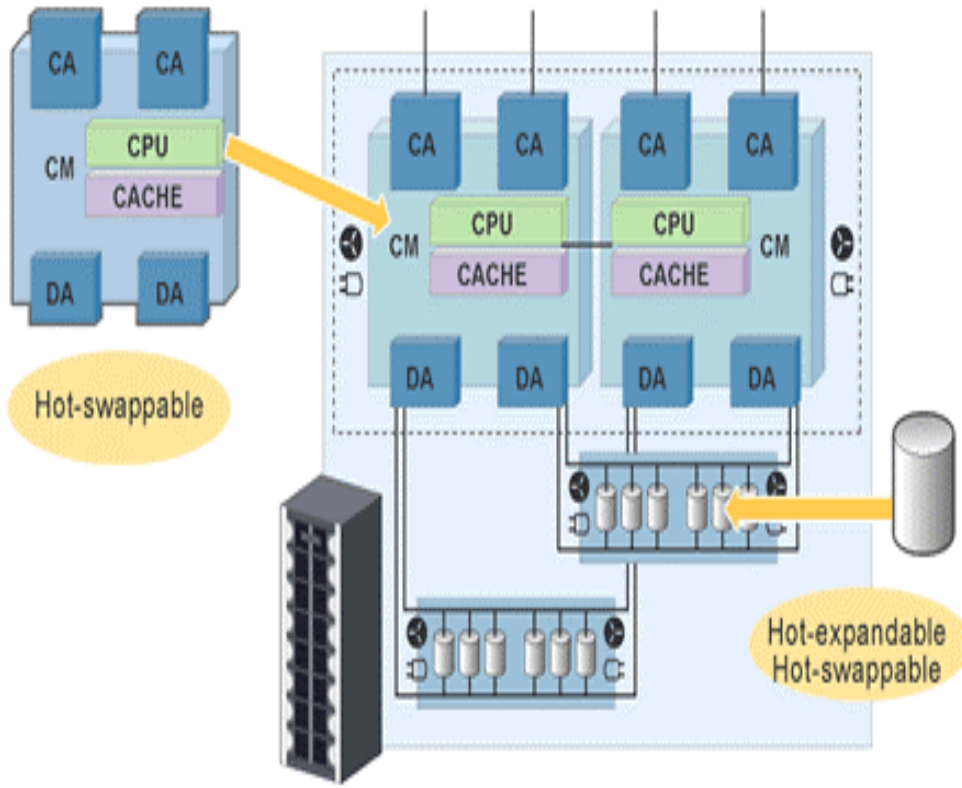


General Approach: Adaptability via Swapping

•Goal: Improve the adaptability of component-based distributed systems.

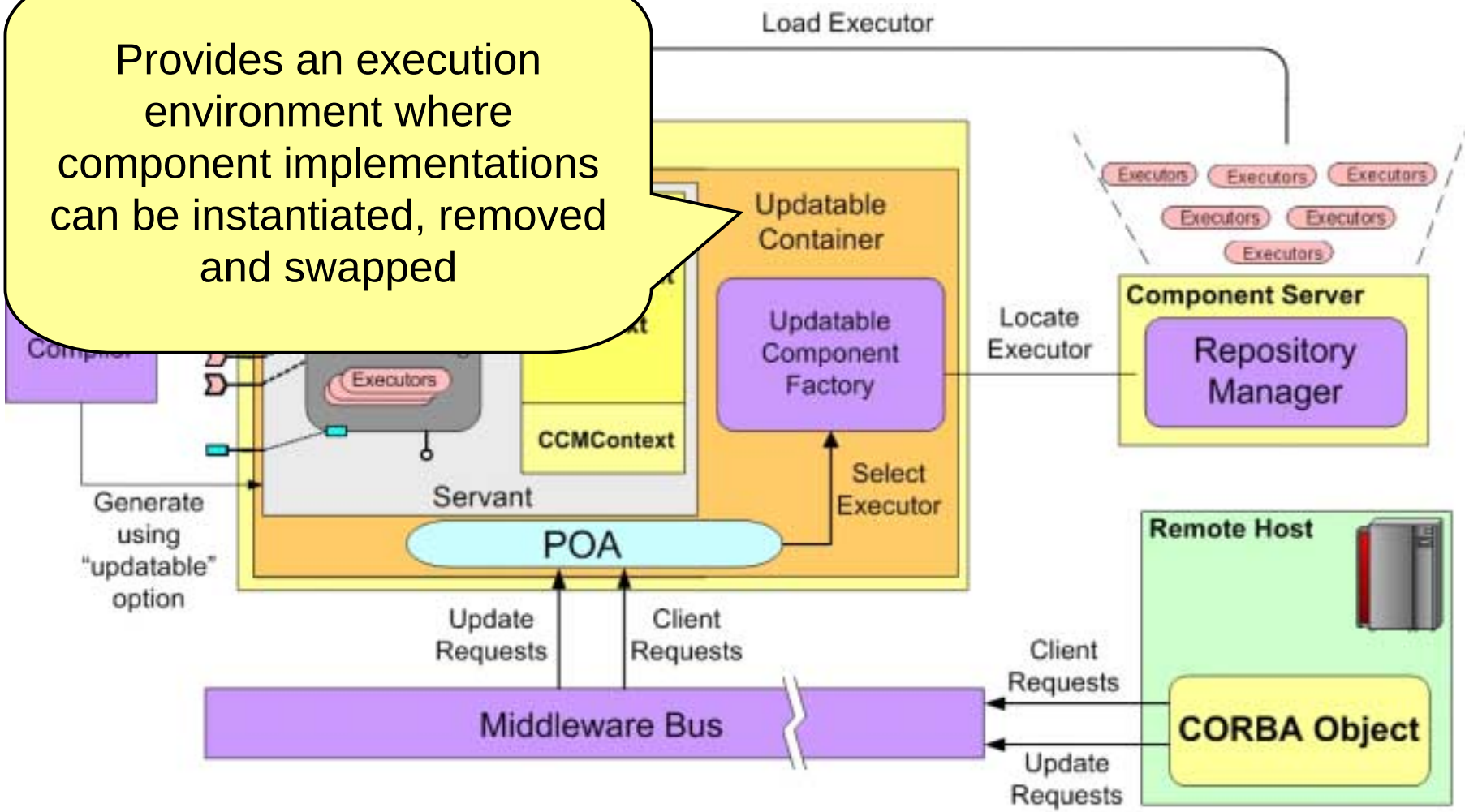
•Requirement: Adaptive and reflective environment where distributed systems can adapt to changing operating conditions.

•Approach: Providing such an environment to dynamically swap component implementations as and when the dynamic operating conditions change.

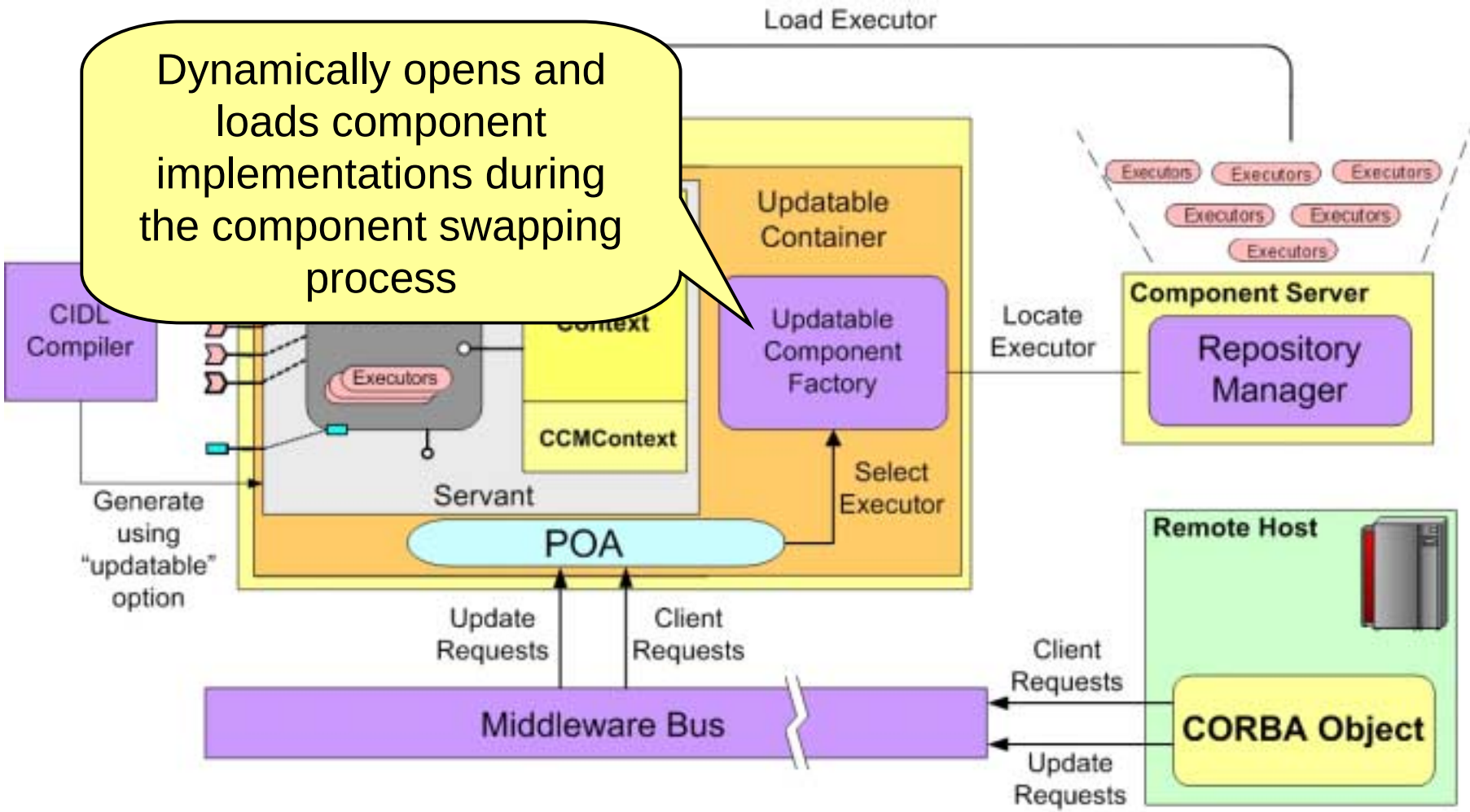


SwapCIAO Architecture (1/4)

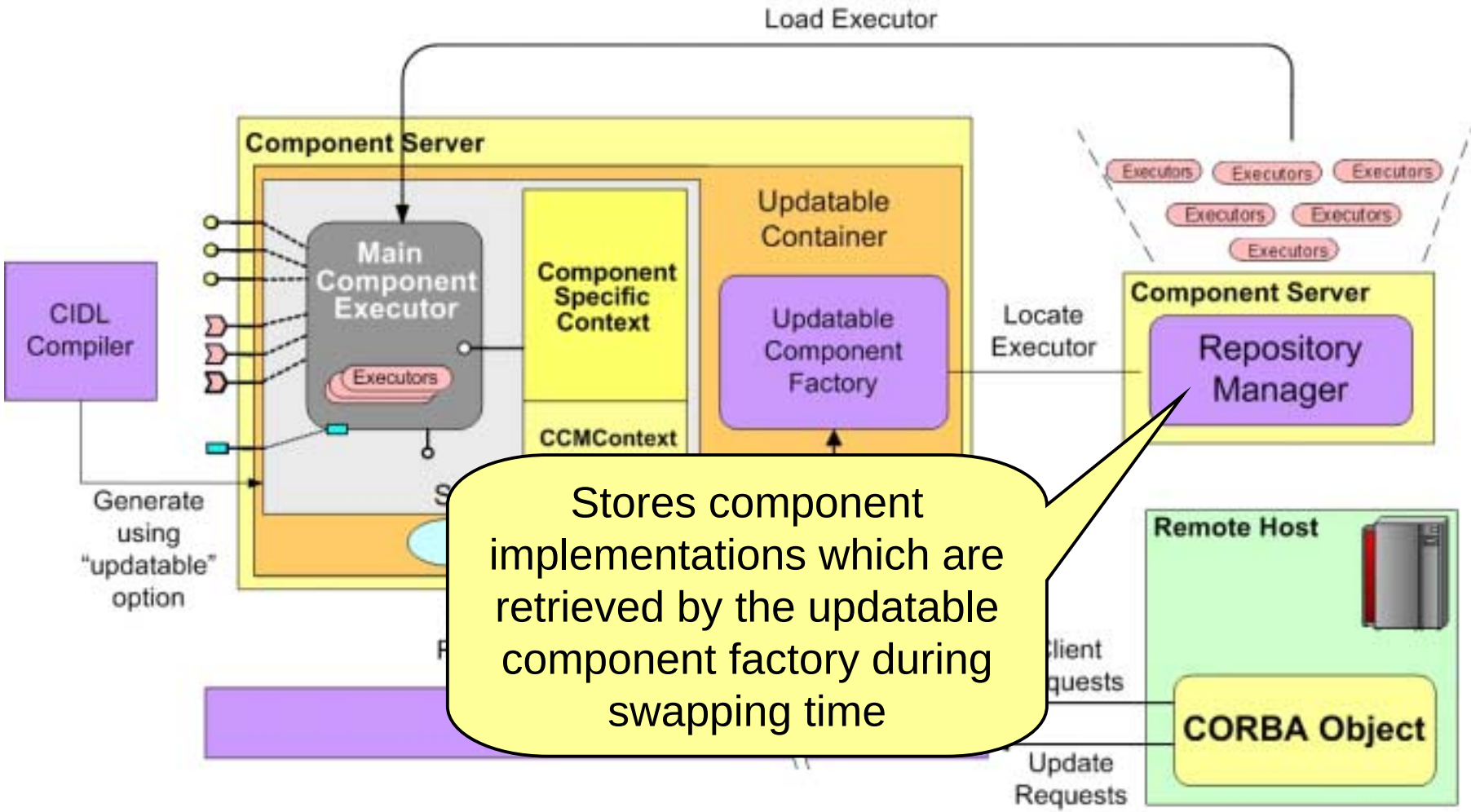
Provides an execution environment where component implementations can be instantiated, removed and swapped



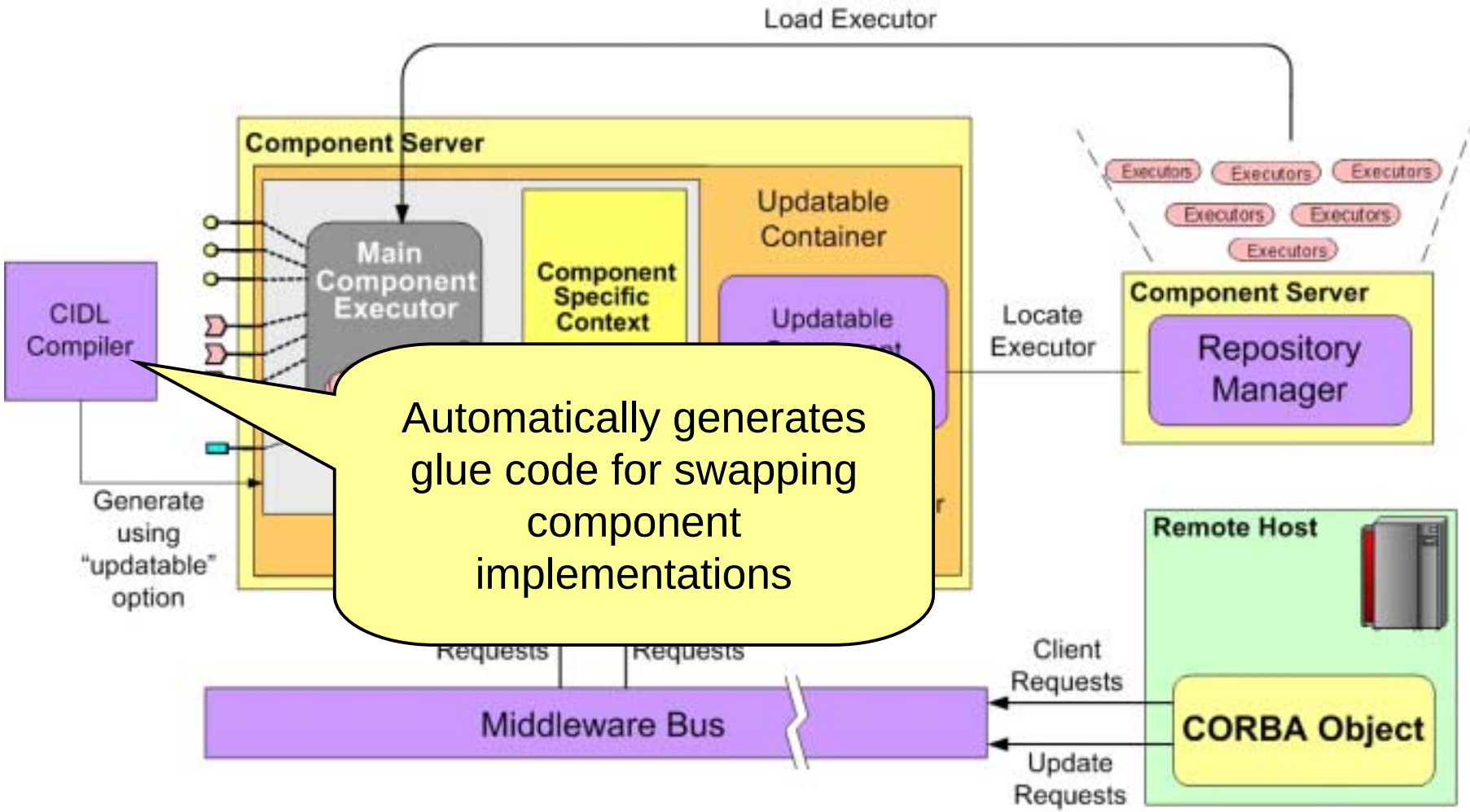
SwapCIAO Architecture (2/4)



SwapCIAO Architecture (3/4)



SwapCIAO Architecture (4/4)



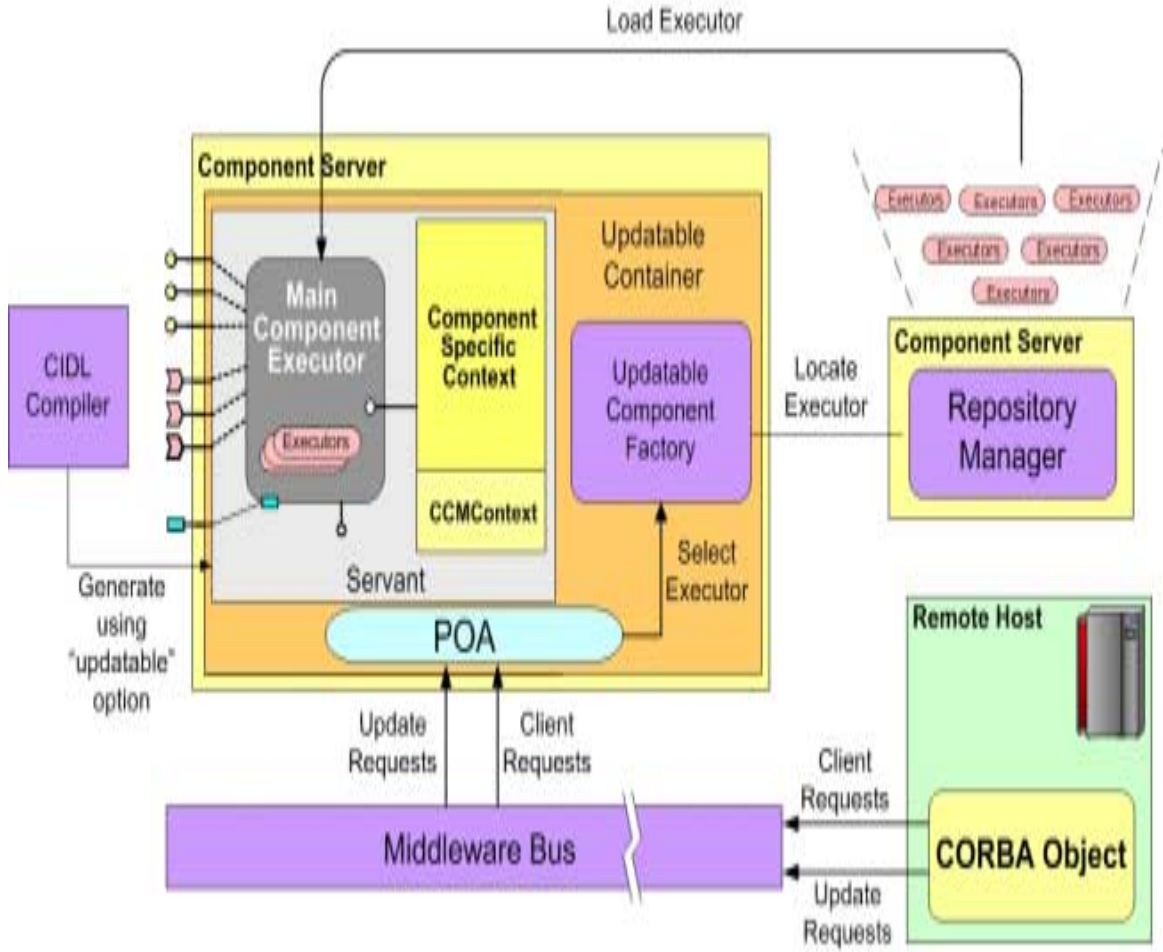
Salient Features of SwapCIAO Architecture

- Updatable Container
  - Extends Lightweight CCM session container interfaces to support additional mechanisms for component creation, activation and swapping.
  - Automatically handles challenges involved in swapping components.

- Updatable Component Factory
  - Extends CCMHome by providing mechanisms for creating component implementations on demand.
  - Can be configured with sophisticated component implementation selection algorithms which can help selecting the right implementation to swap during the component swapping process.
  - Provides a portable interface for opening DLLs on heterogenous run-time platforms.

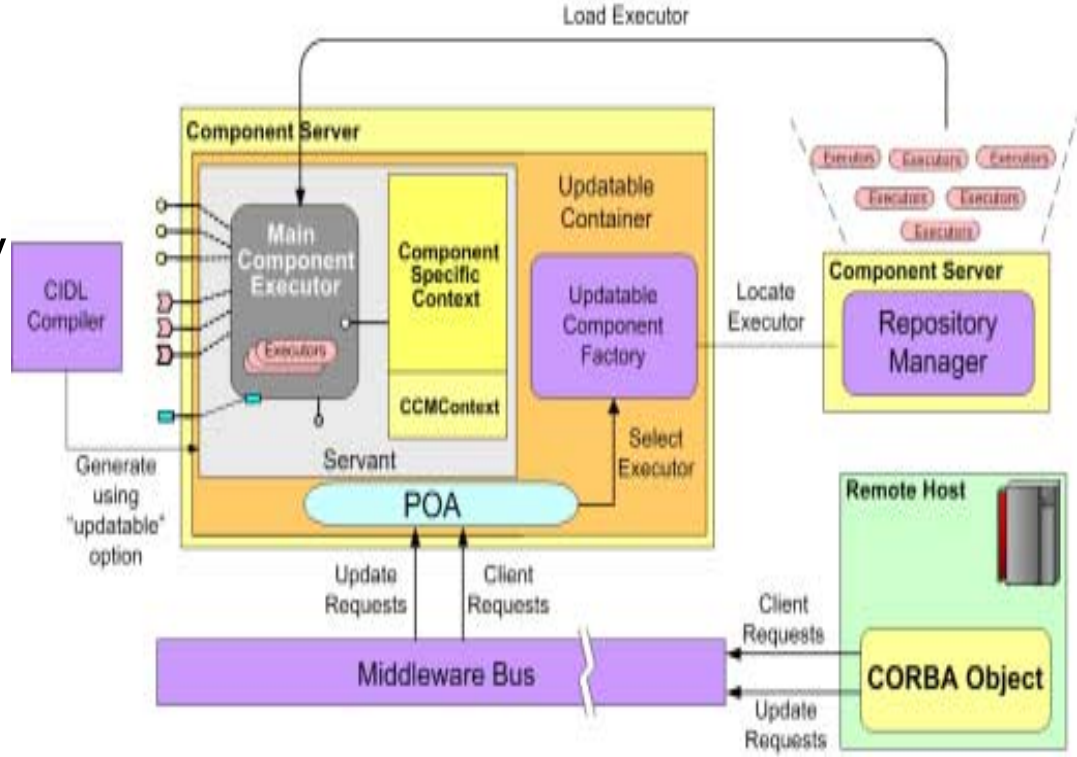
Providing Consistent and Uninterrupted Swapping (1/2)

- Clients can initiate new invocations when dynamic swapping takes place
  - These invocations should be blocked and allowed into the system after the swapping finishes.
- Ongoing invocations could be processed when dynamic swapping happens
  - These invocations must be allowed to complete before swapping starts.



Providing Consistent and Uninterrupted Swapping (2/2)

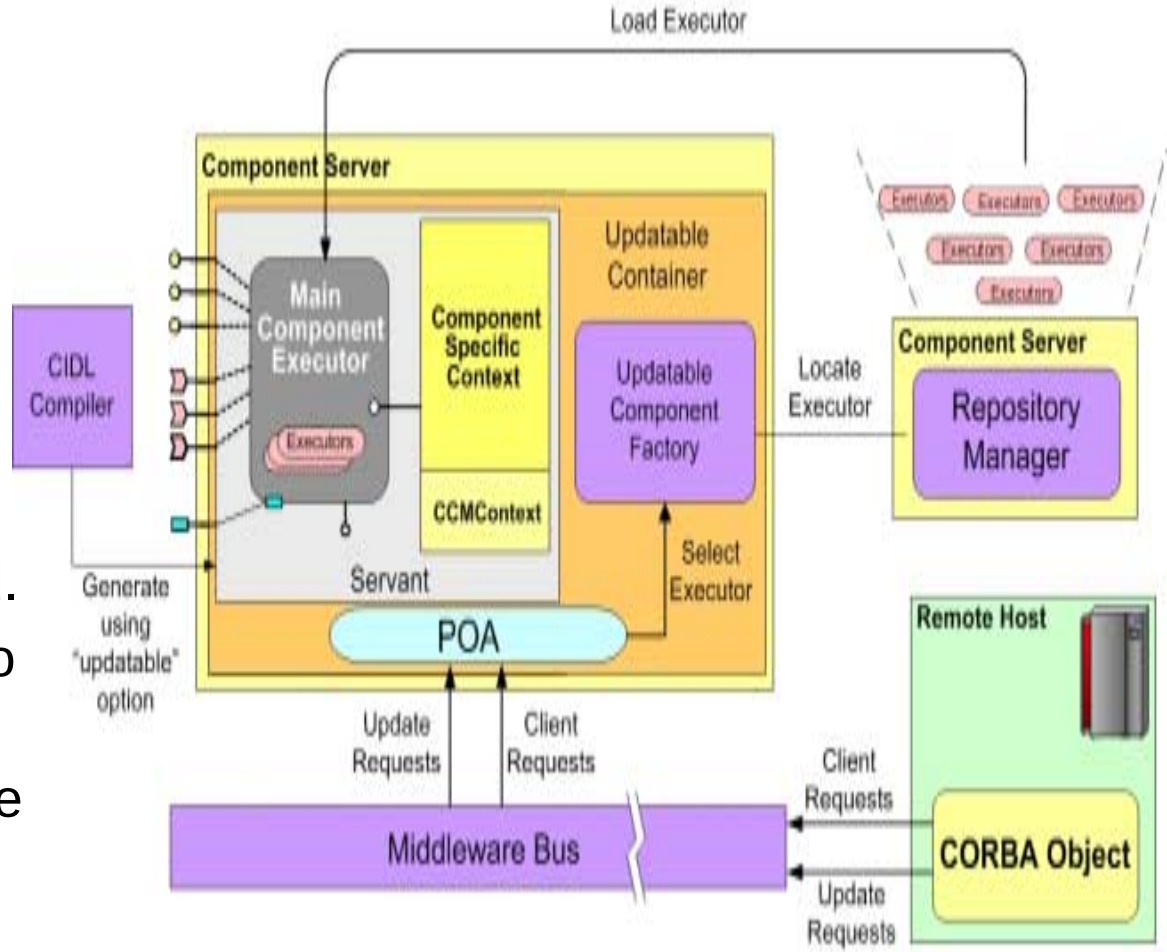
- Ongoing invocations need to complete processing.
  - Maintain a dispatch table at the POA and track how many requests processed in each thread
  - Use standard reference counting and deactivation mechanisms to delete a component only when the dispatch table count is zero.



- Block new invocations from entering the system.
  - Updatable container instructs the ORB to block invocations using standard CORBA Portable Interceptors.

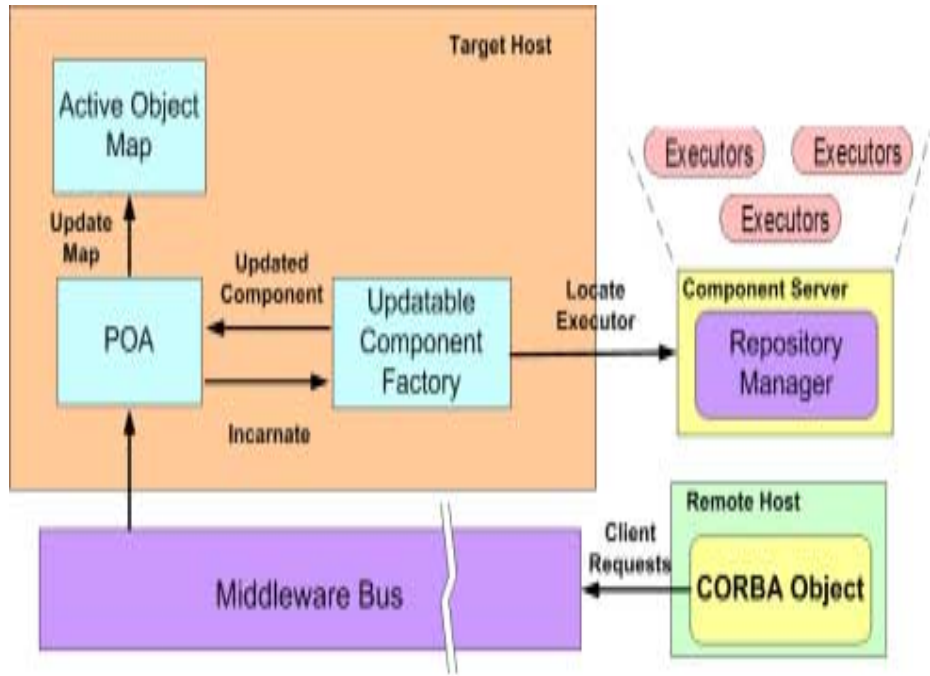
Providing Client Transparent Swapping (1/2)

- Clients hold an object reference to the component to make an invocation.
- During swapping, the old component is removed and the new component implementation is loaded.
- Old component reference held by client no longer valid.
- Dynamic swapping needs to be transparent.
  - Clients should not update their references and still not receive invalid reference exceptions



Providing Client Transparent Swapping (2/2)

- POA intercepts client requests after the component is removed.
- Active Object Map will be empty if component is removed already.
- Associate the POA with servant activator.
- Register the updatable component factory with the servant activator.
- If no component available, the servant activator automatically calls the updatable component factory to create new implementation.



- Store the new implementation in the POA's Active Object Map.
  - Activate component servants with unique user id, so that clients need not be updated with the new reference, preventing roundtrip delays informing the client about the new component.

Conclusion

- SwapCIAO is a component middleware framework based on Lightweight CCM that supports dynamic component updating.
- SwapCIAO is designed to handle dynamic operating conditions by swapping component implementations that are optimized for particular run-time characteristics.
- Standard Lightweight CCM interfaces can be extended to develop a scalable and flexible interface for supporting dynamic component updating.
- Hence client programming model and the client/server interoperability were unaffected by the new interfaces added.
- Developers of client/server applications need not do anything special to get the benefits of swapping component implementations.