

Intelligent Agents in Industrial Control

Duncan McFarlane

Agent Showcase

September 2003



Showcase Overview

Duncan McFarlane



Aims of Showcase

- To provide an introduction to software agents and related technologies
- To establish a role for agents in industrial control
- To demonstrate that agents are becoming compatible with today's commercial software and industrial control hardware



Agenda

*Duncan McFarlane:
(Univ of Cambridge)*

*Welcome / Agent Overview /
State of Deployment*

*Andre Lucas:
(Agent Oriented*

*Commercialising Agent Software
Software)*

*Filip Macurek :
(Rockwell Automation)*

*Developing Agent based solutions
for Industrial Control Systems*



Software Agents in Industrial Control

Duncan McFarlane



Overview

- **CDAC Introduction**
- **What are agents?**
- **Why Agents in Industrial Control?**
- **How does an Agent Based Control System Work?**
- **What is being Done?**



Centre for Distributed Automation and Control

- Providing a focus for education and research in manufacturing supply chain automation
- Supporting and maintaining an active, participation based network
- A source of knowledge and expertise for industrial practice
- Establishing and maintaining collaborative R&D relationships with key companies



CDAC Research Strategy

Business Focus:

Understanding and improving the ability of manufacturing production to thrive in the face of unpredictable **disturbances** & increasing **change**



Technology Focus:

Development of **adaptable algorithms and reconfigurable control architectures** to support the development of **distributed, intelligent manufacturing systems & devices**



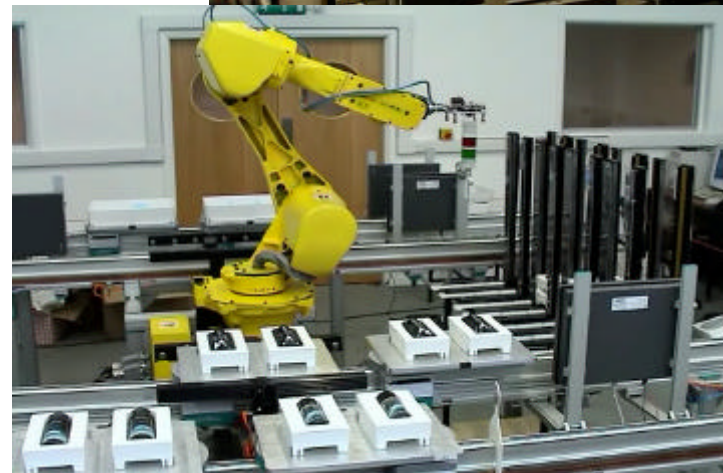
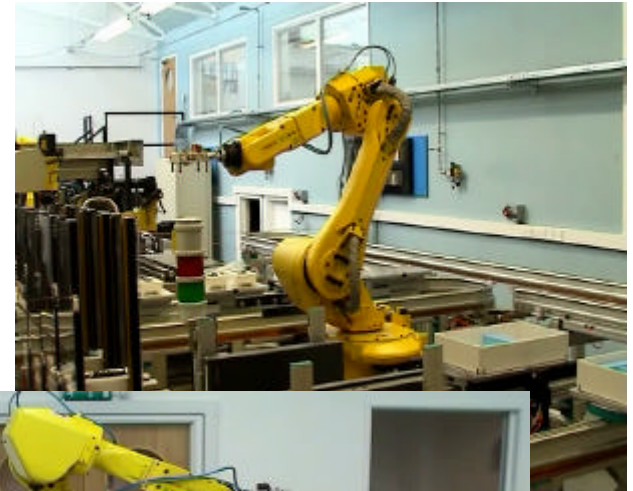
Emerging Focus:

Application of distributed intelligent technologies to provide support for agile, product-driven supply chains



Automation Laboratory

- centre piece to CDAC activities
- enormous development over 7 years
- industrial strength testing of research developments



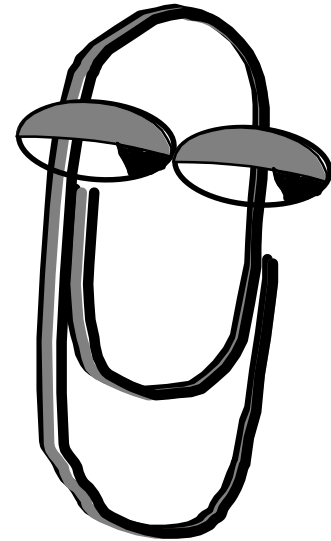
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- How does an Agent Based Control System Work?
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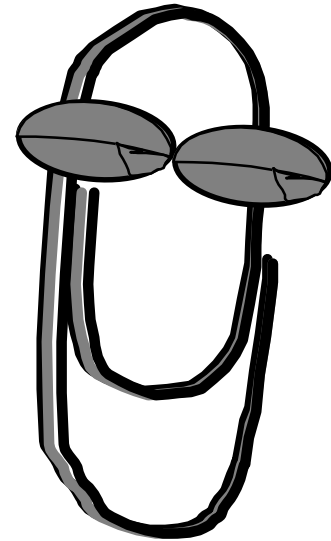
Software Agents

A distinct software process, which can reason independently, and can react to change induced upon it by other agents and its environment, and is able to cooperate with other agents.



Software Agents

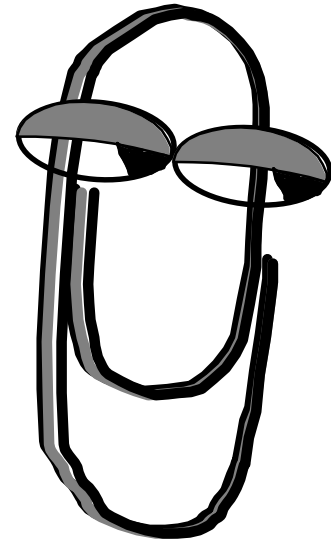
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Software Agents

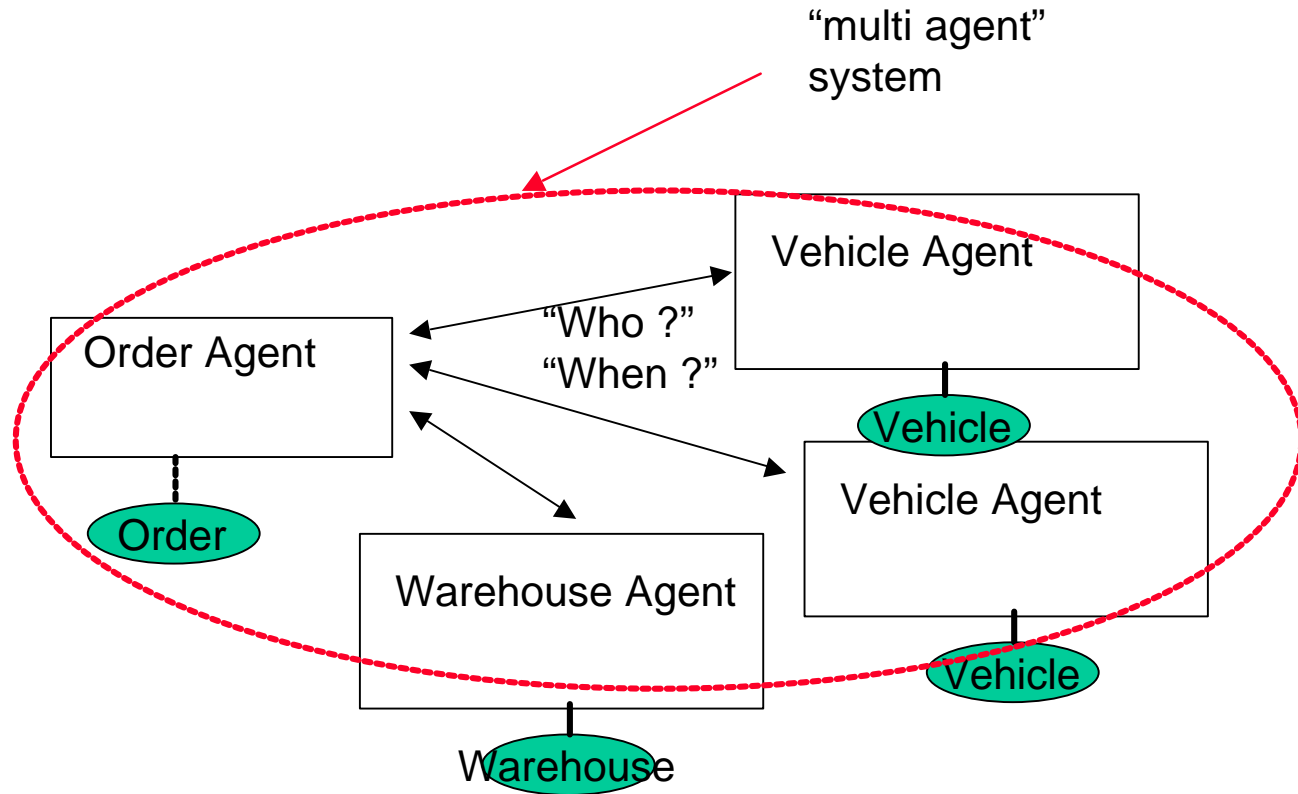
A distinct software process, which can reason independently, and can react to change induced upon it by other agents and its environment, and is able to cooperate with other agents.

- Part of Artificial Intelligence research
- Used in problems that are highly distributed e.g.
 - *Electronic Transactions*
 - *Parallel Computing*
 - *Distributed planning and scheduling*
- In the supply chain, agents provide a means of attaching “intelligence” to individual orders or products or machines ...



How do agents work?

- few *fixed* operations
- decisions made by local Agents
- interactions between agents via negotiation



Agent roles in an Industrial Context?

- schedule solvers for complex distributed operations (*intelligent scheduling*)
- routing, real time execution algorithms (*multi agent control systems*)
- decision support systems for self contained, “plug and play” manufacturing units (*holonic manufacturing systems*)

.... Why?



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Manufacturing Supply Chain Trends

- Growing manufacturing capacity surplus gives customers greater choice
 - Increase competition between suppliers
 - Customers less brand loyal



- **Manufacturers must**
 - Shorten product lifecycles
 - Reduce time-to-market with new innovations
 - Manage increased product variety/complexity/NPI
 - Rapidly satisfy demand
 - Maintain quality
 - Reduce costs

... move away from a production line view of the world ...

Source: A McDonald, Unilever HPC



(Control) System Implications

- **Robustness:** to maintain performance in face of disruption
- **Flexible:** to enable seamless adaptation to new circumstances
- **Scalable/Reconfigurable:** to enable rapid adjustment to changing volume/variety/technology
- **Standardisation:** to enable interchangeable products, equipment and systems

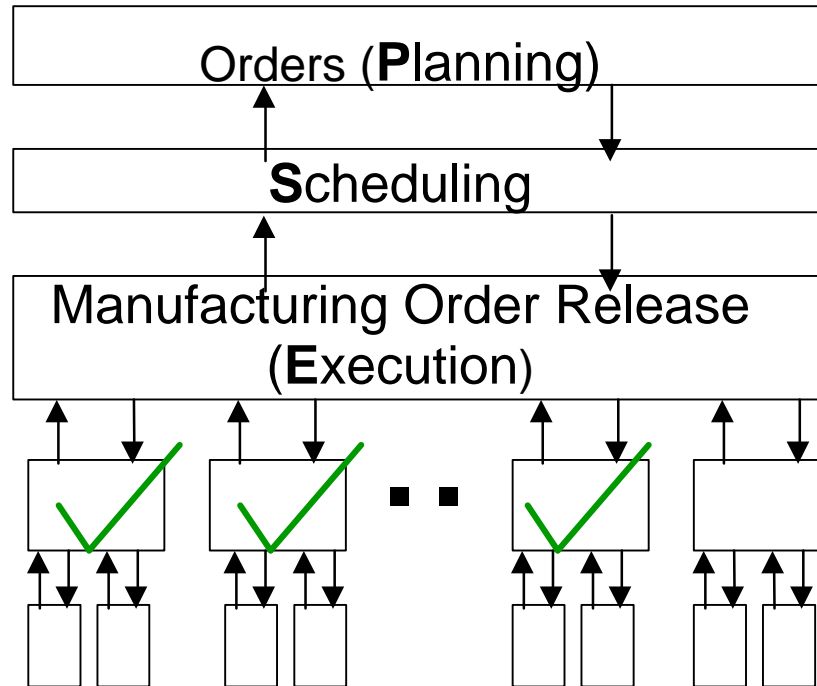


Existing Control Approaches

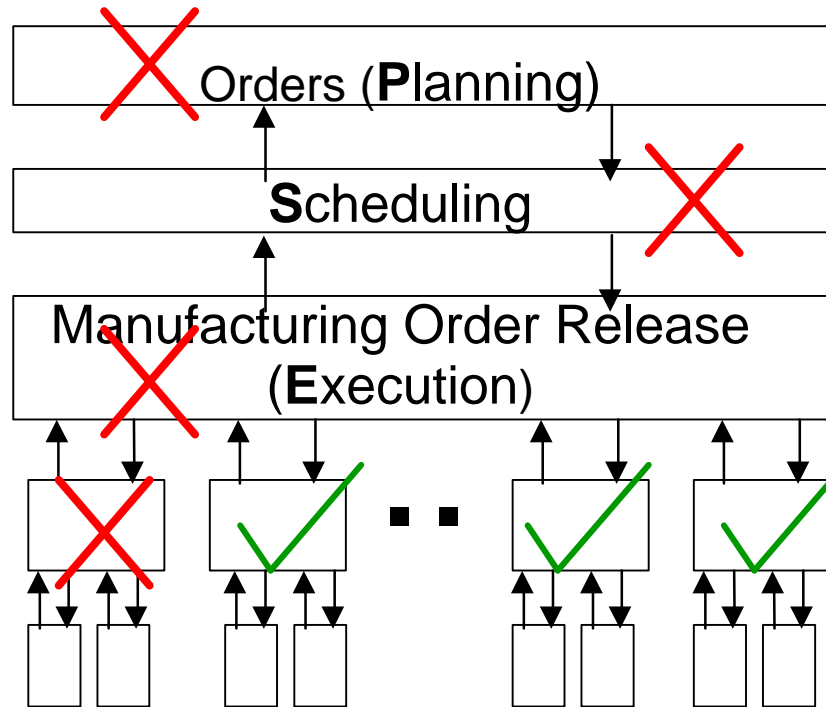
- Conventional planning and control approaches will no longer be able to support a manufacturing operation attempting to meet increasingly difficult demands
 - Current systems are hierarchical
 - Costly to maintain
 - Difficult, costly and take time to modify
 - Rely upon costly specialists



Existing Control Approaches



Existing Control Approaches



Why Use Agents in Industrial Control?

Non fixed decision making, distributed negotiation

=> Adaptive and flexible control response

=> robust operational performance

Modular Software, ability to self configure

=> Ease of configuration, reconfiguration, system re organisation

=> plug and play control system performance



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Common Agent Types

Order agent - OA

- a unit representing the requirements of a particular order, including information such as product qualities, due dates, costs, priorities. It may also encompass physical products

Resource agent - RA

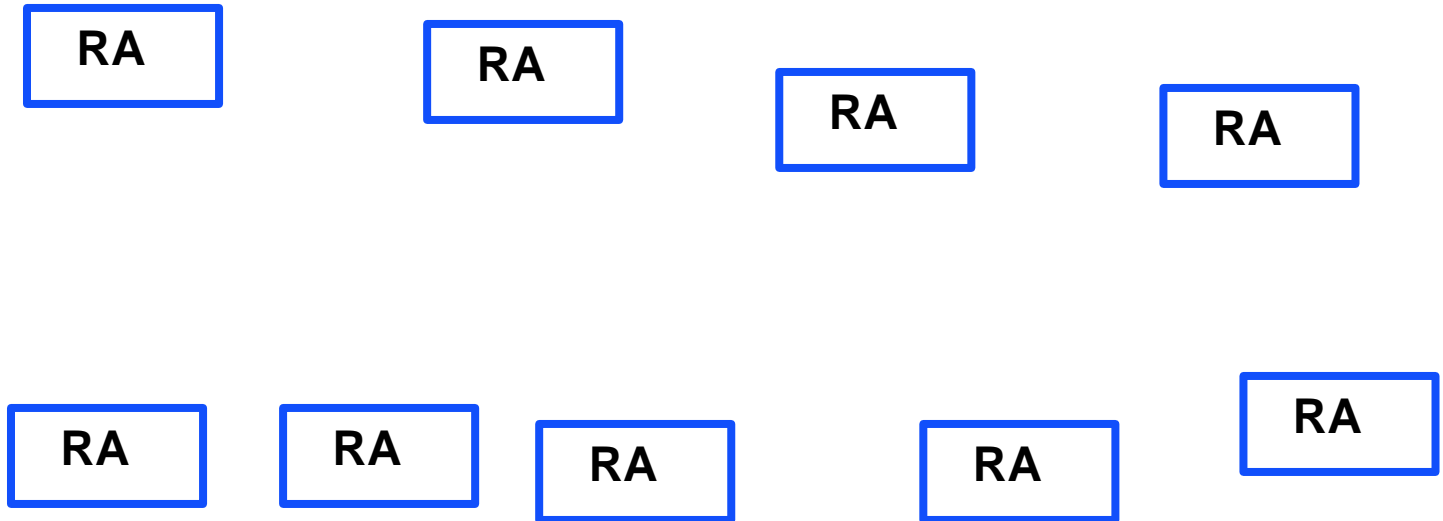
- a single unit comprising one or more physical processes or transportation resources, its control & decision systems

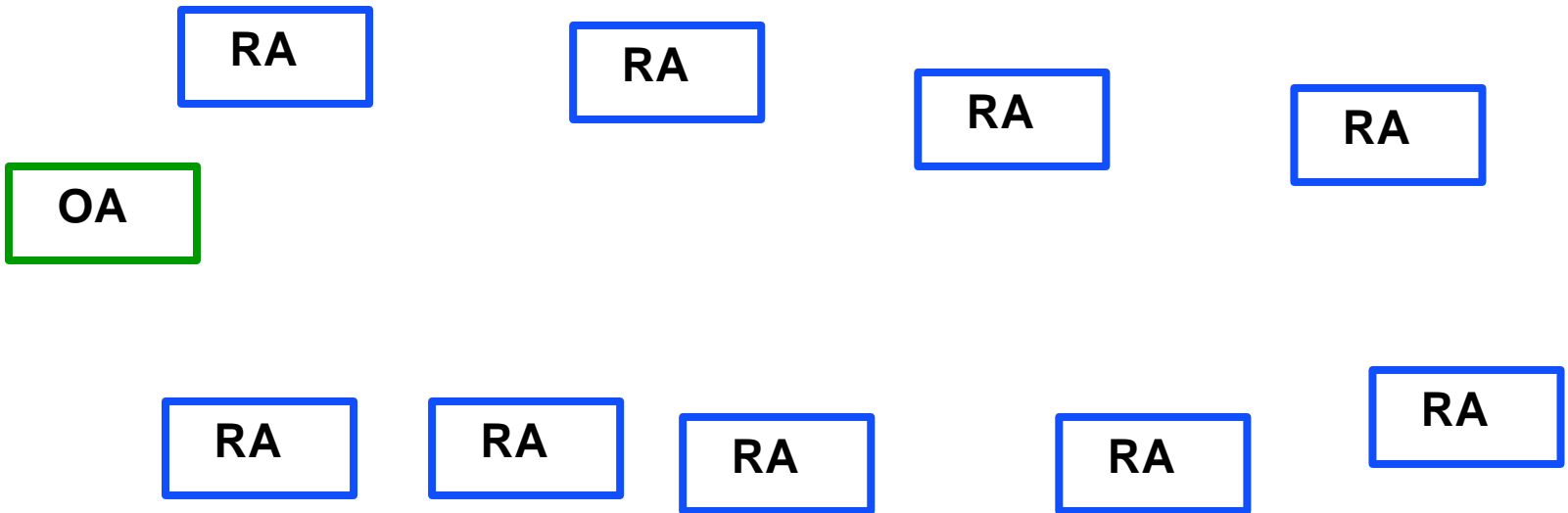
Product agent - PA

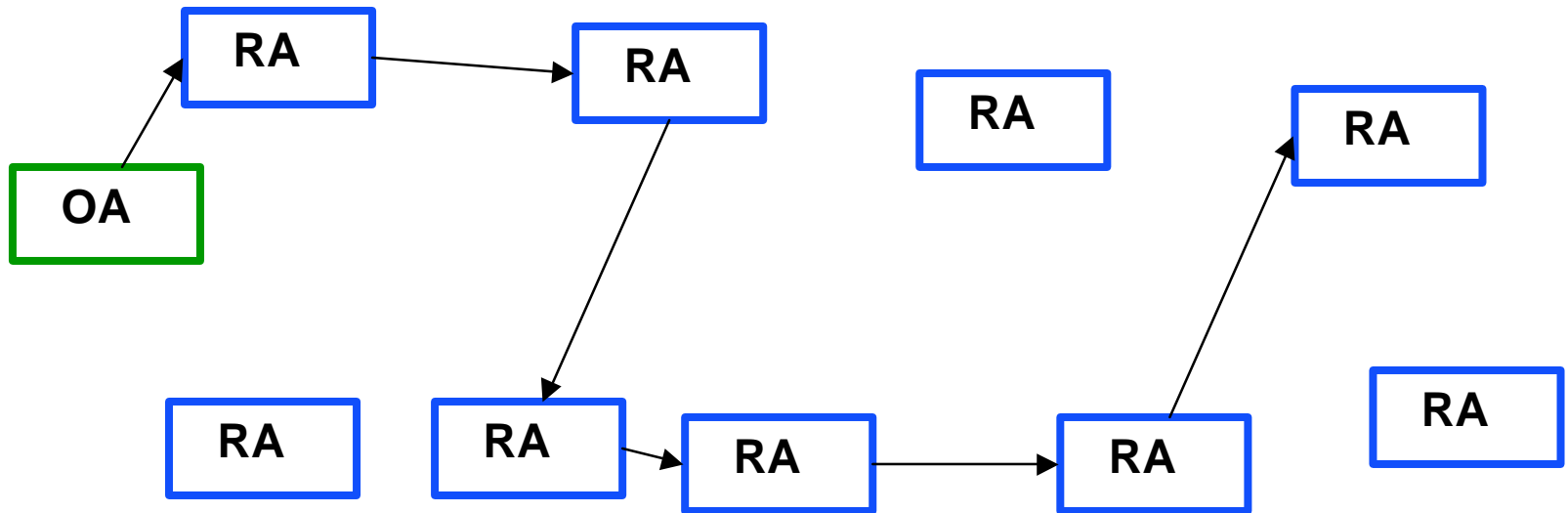
- a unit comprising the physical product being produced and the human and computing support necessary to initiate and monitor the act of producing it.

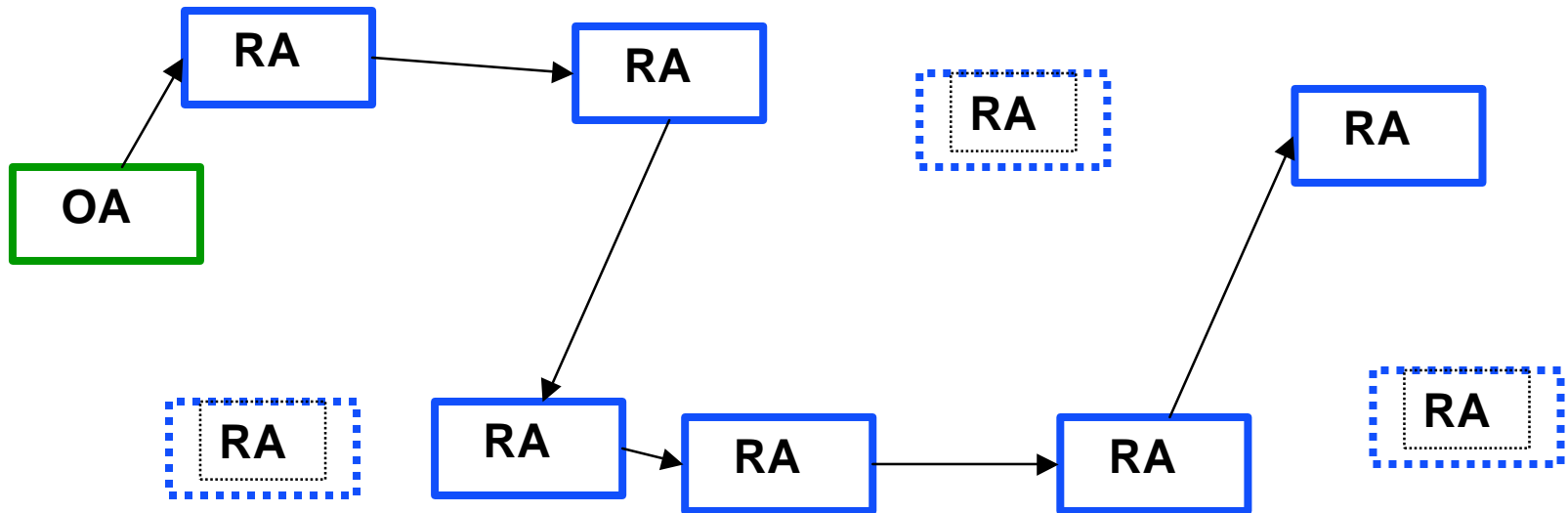


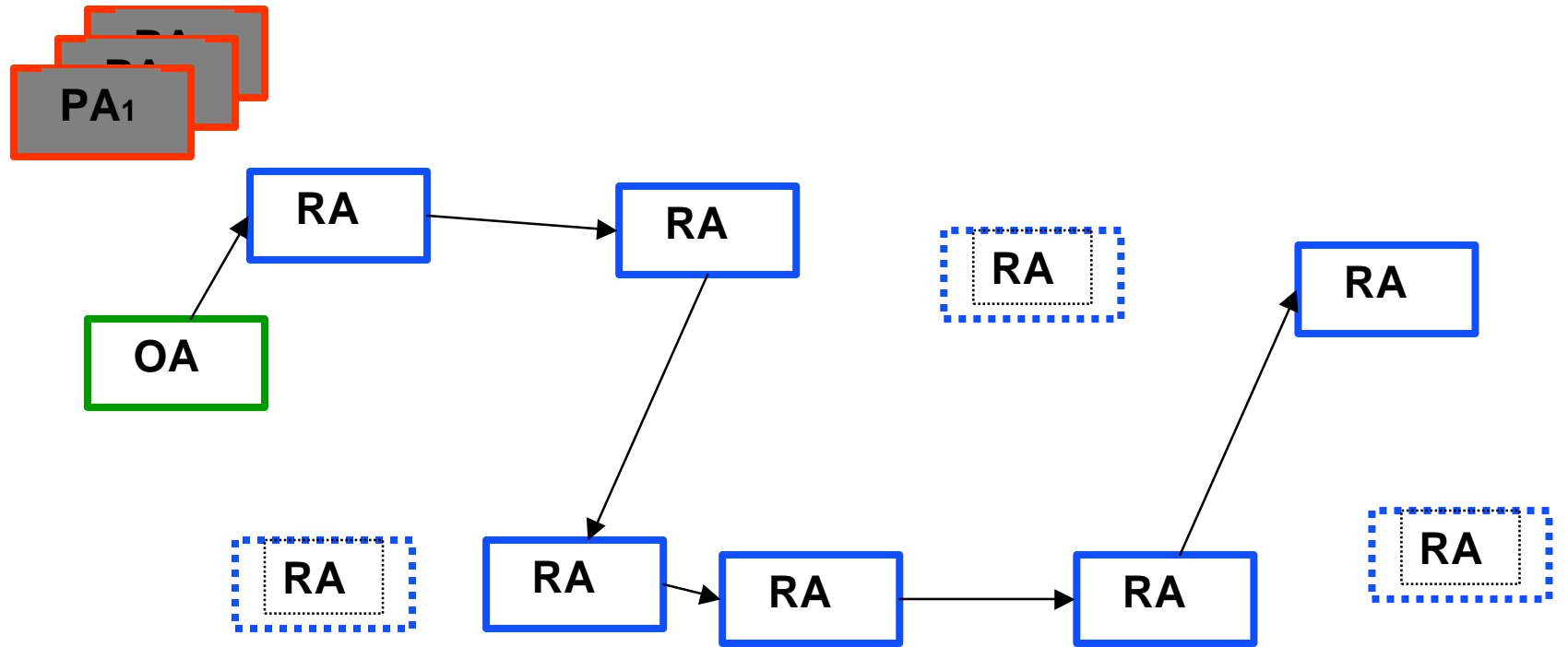
Example 1: Order Fulfilment

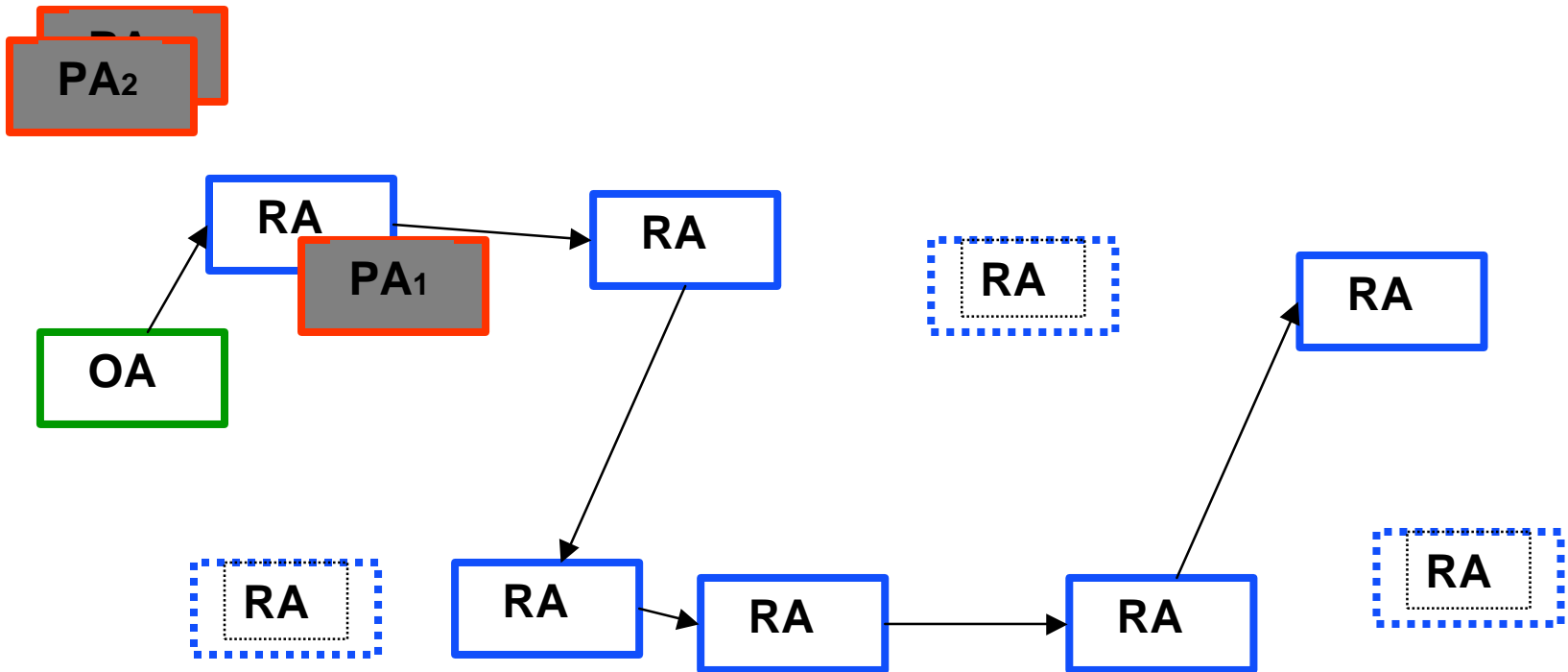


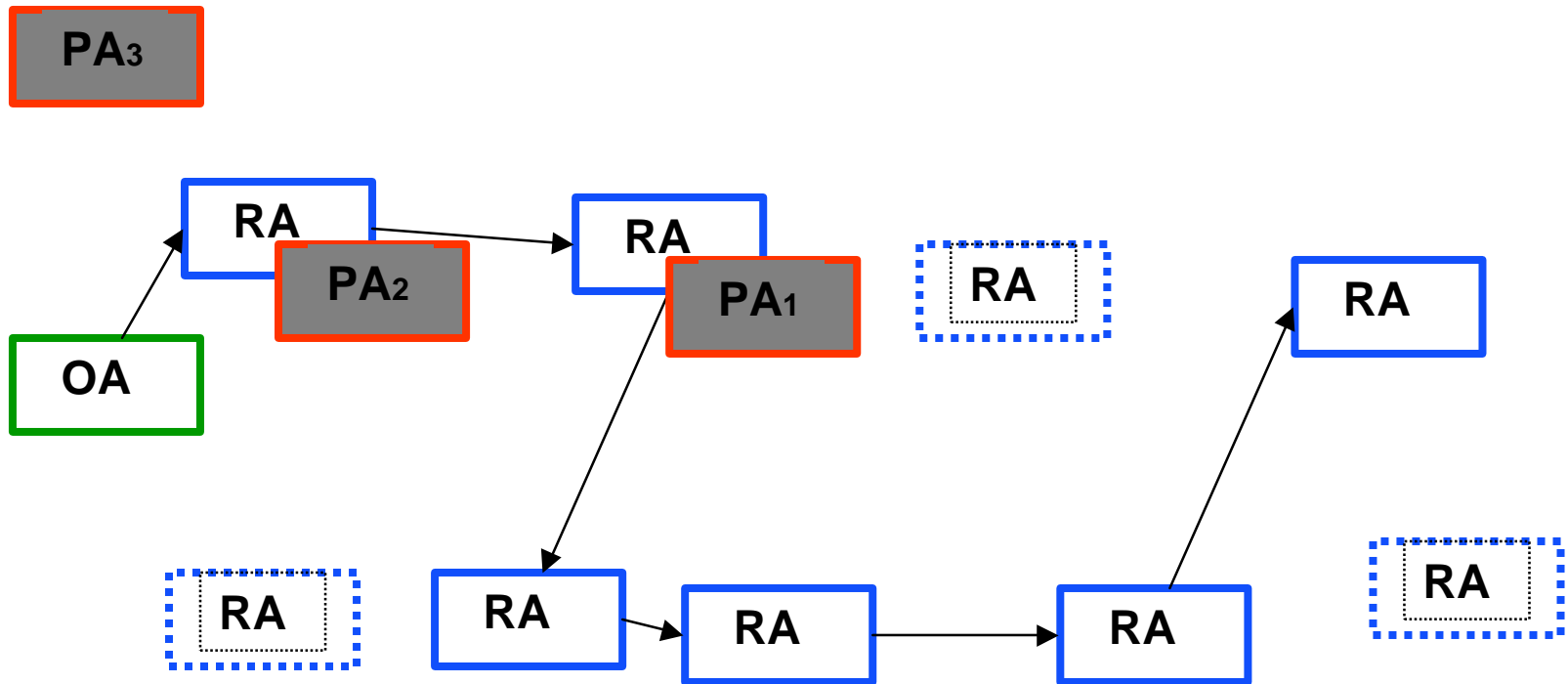


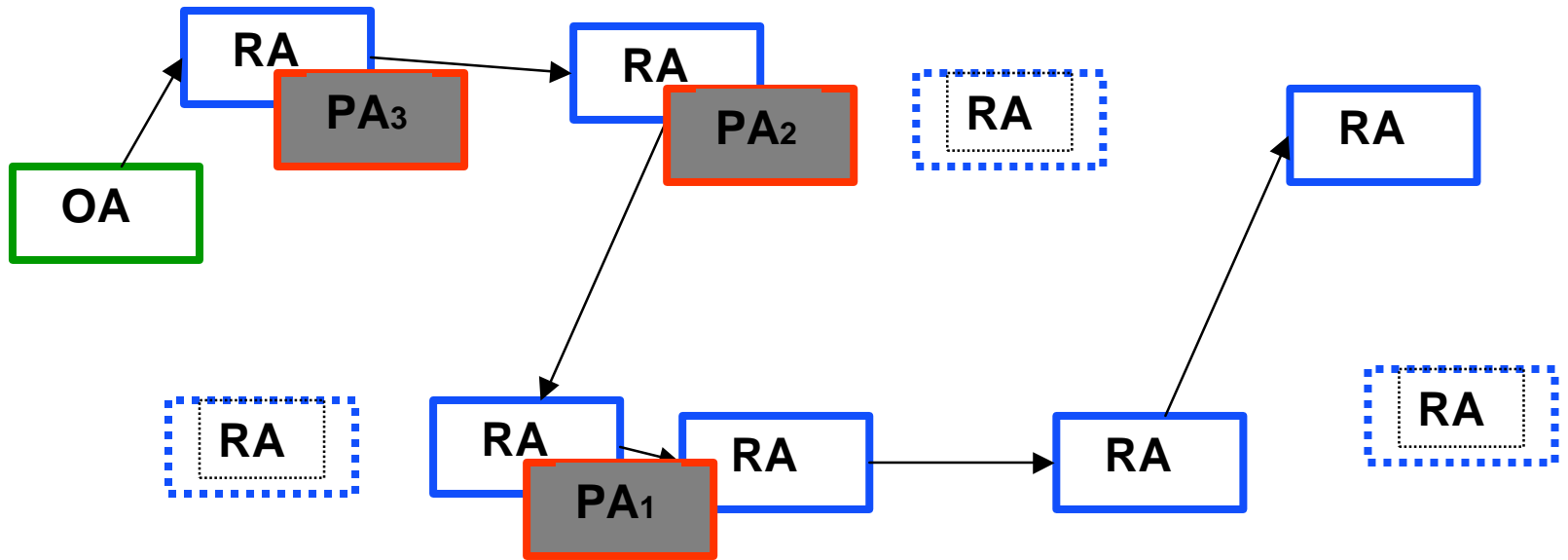


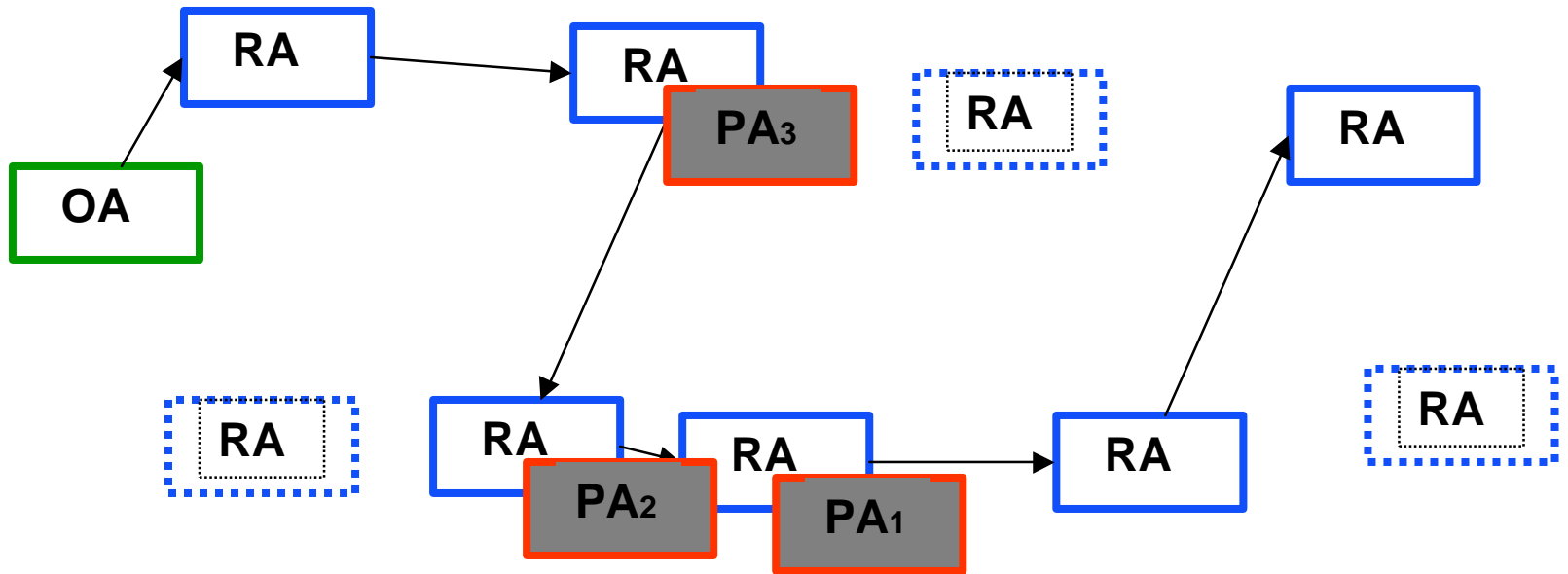


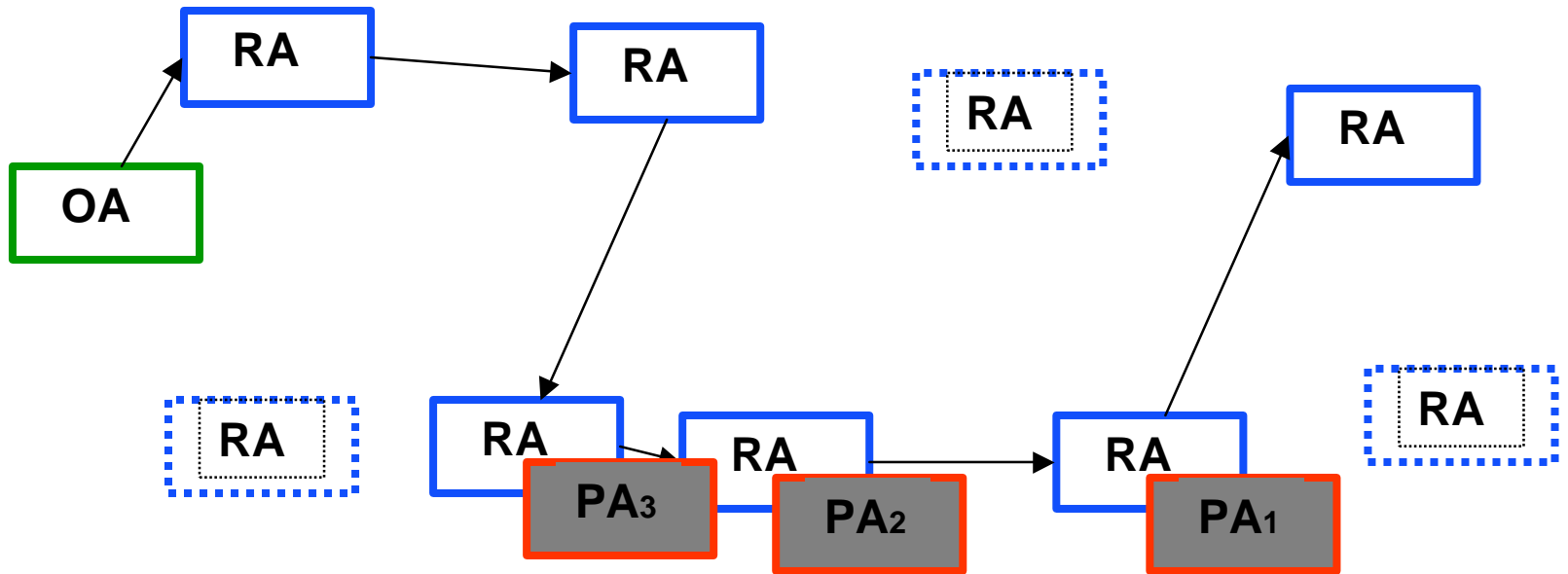


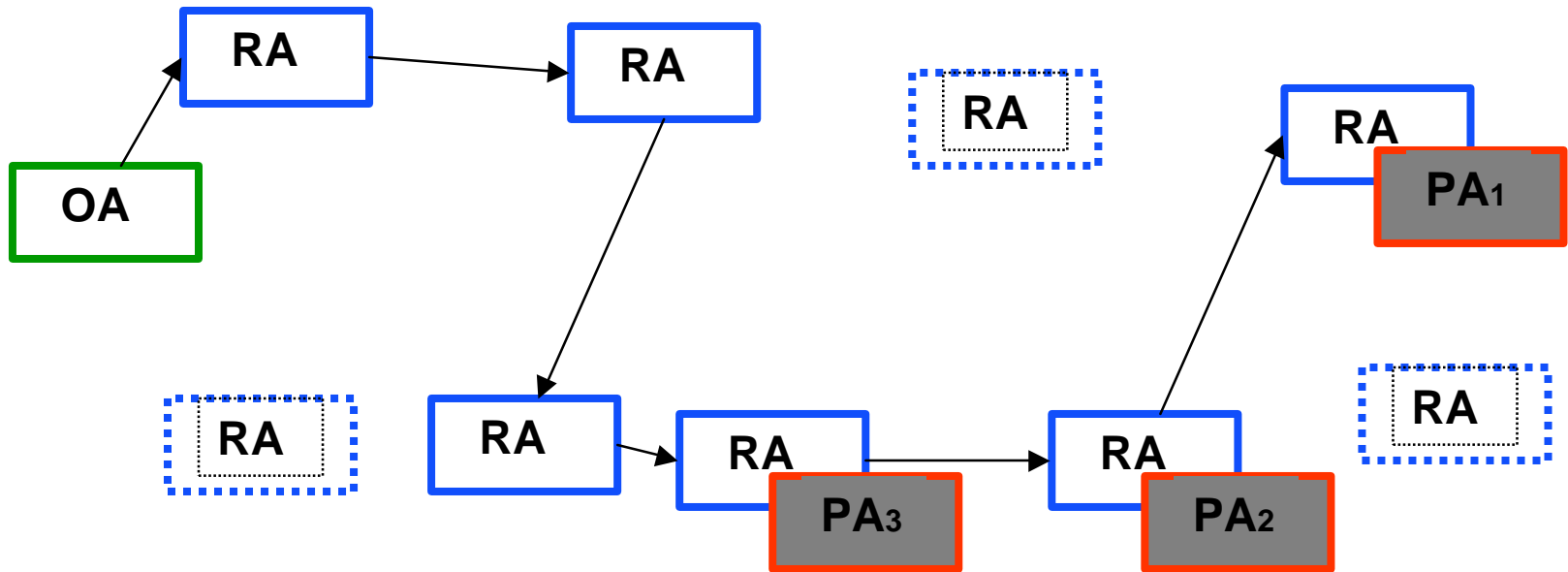


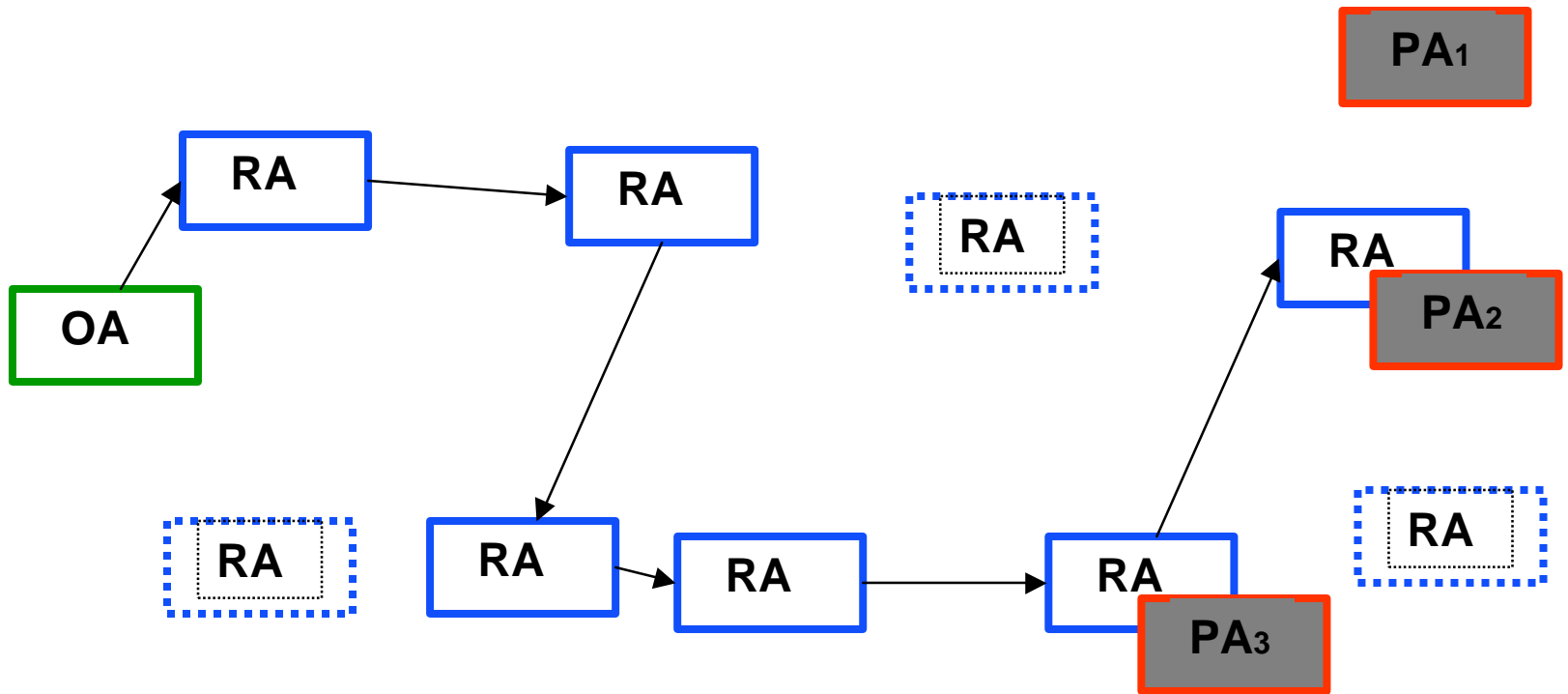


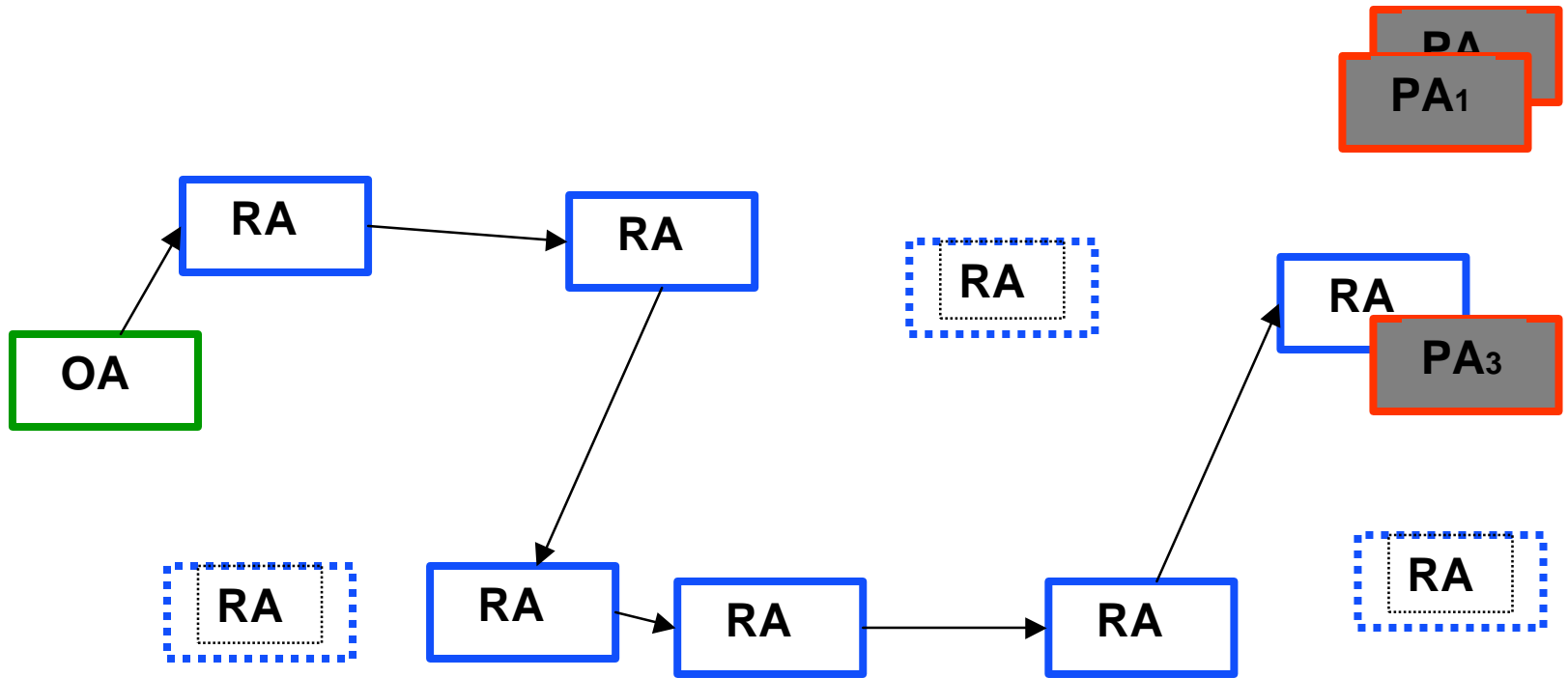


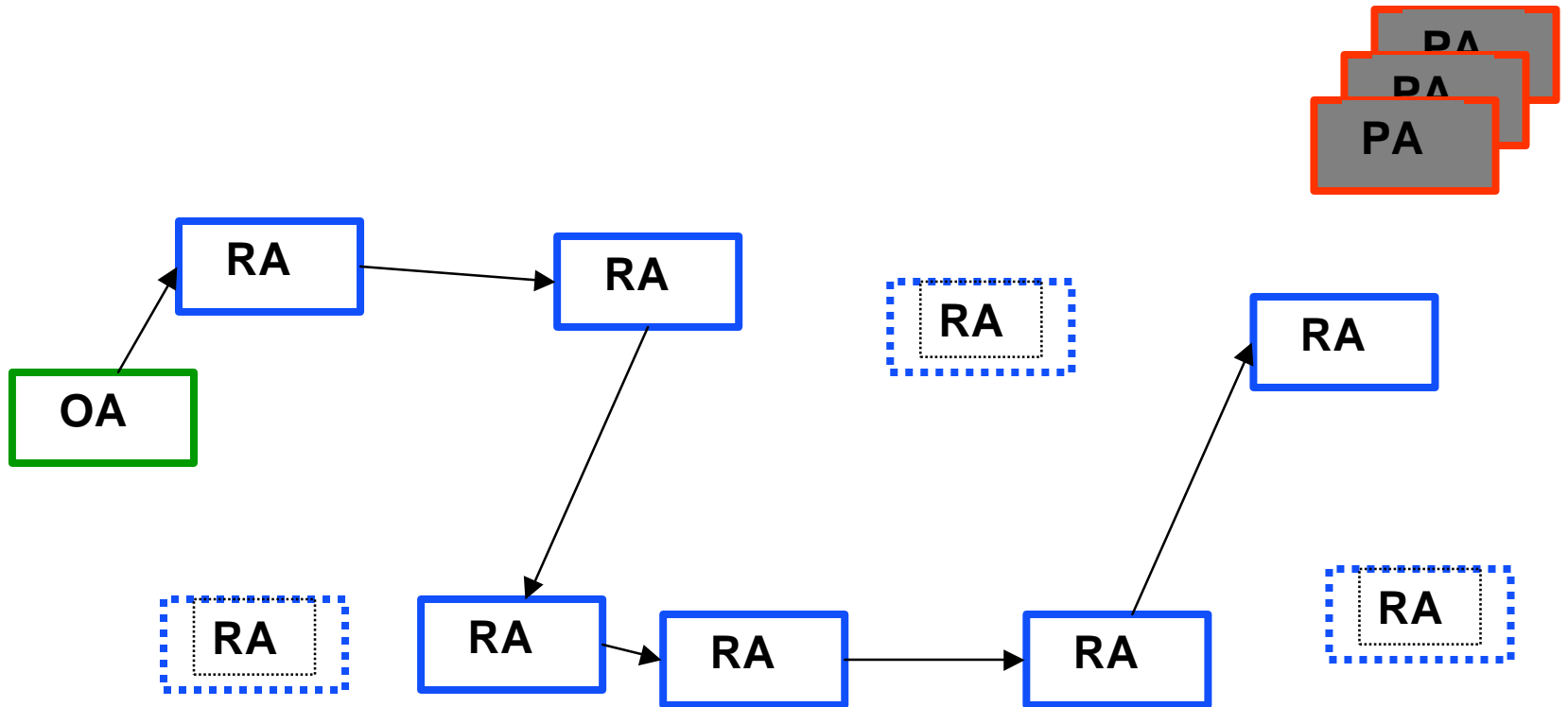




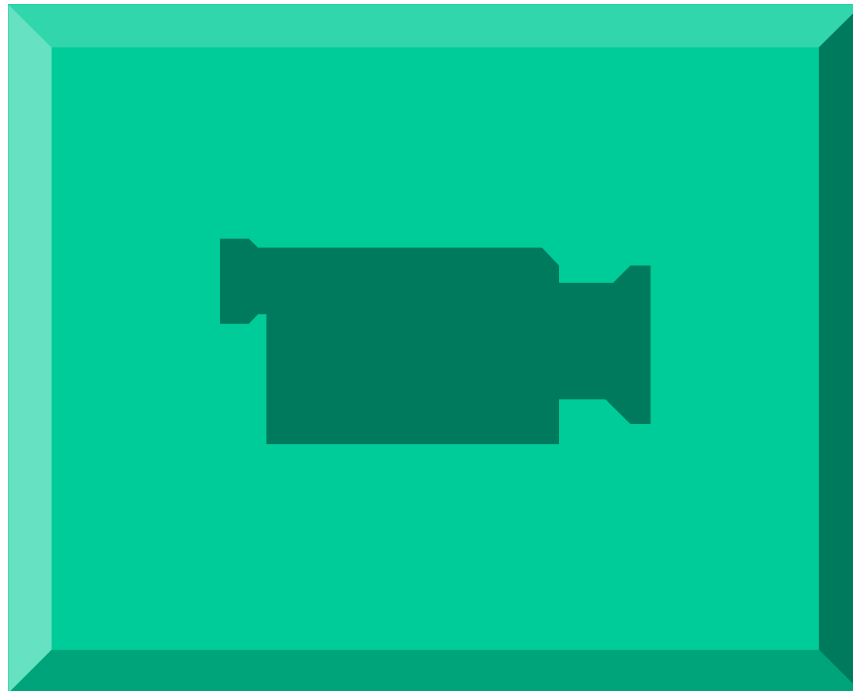




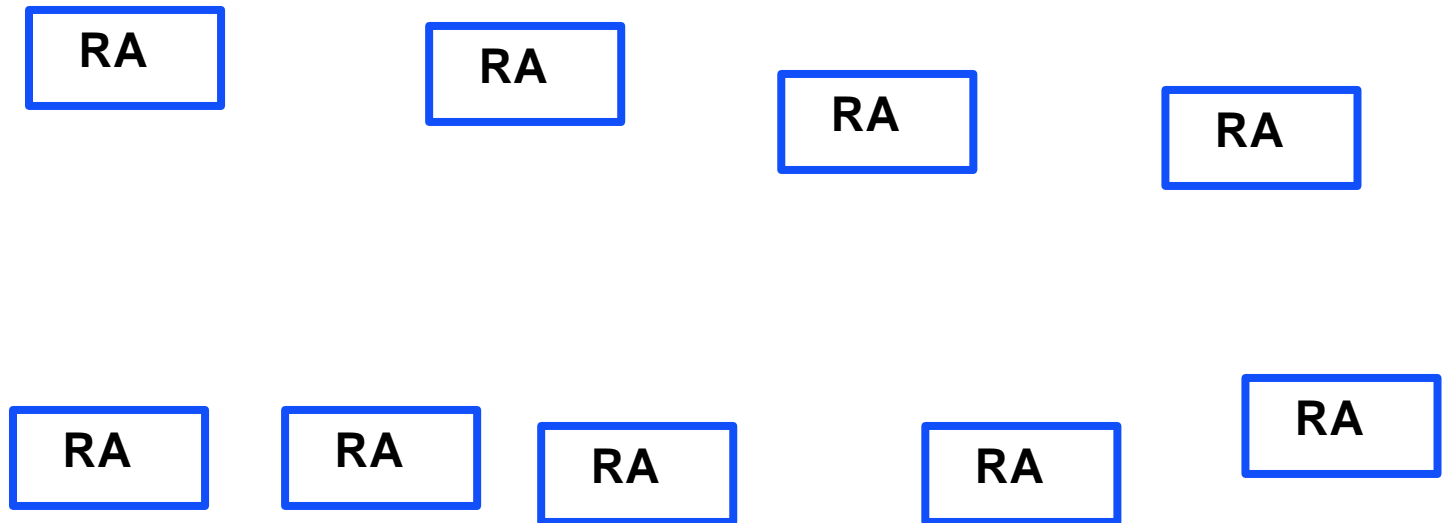


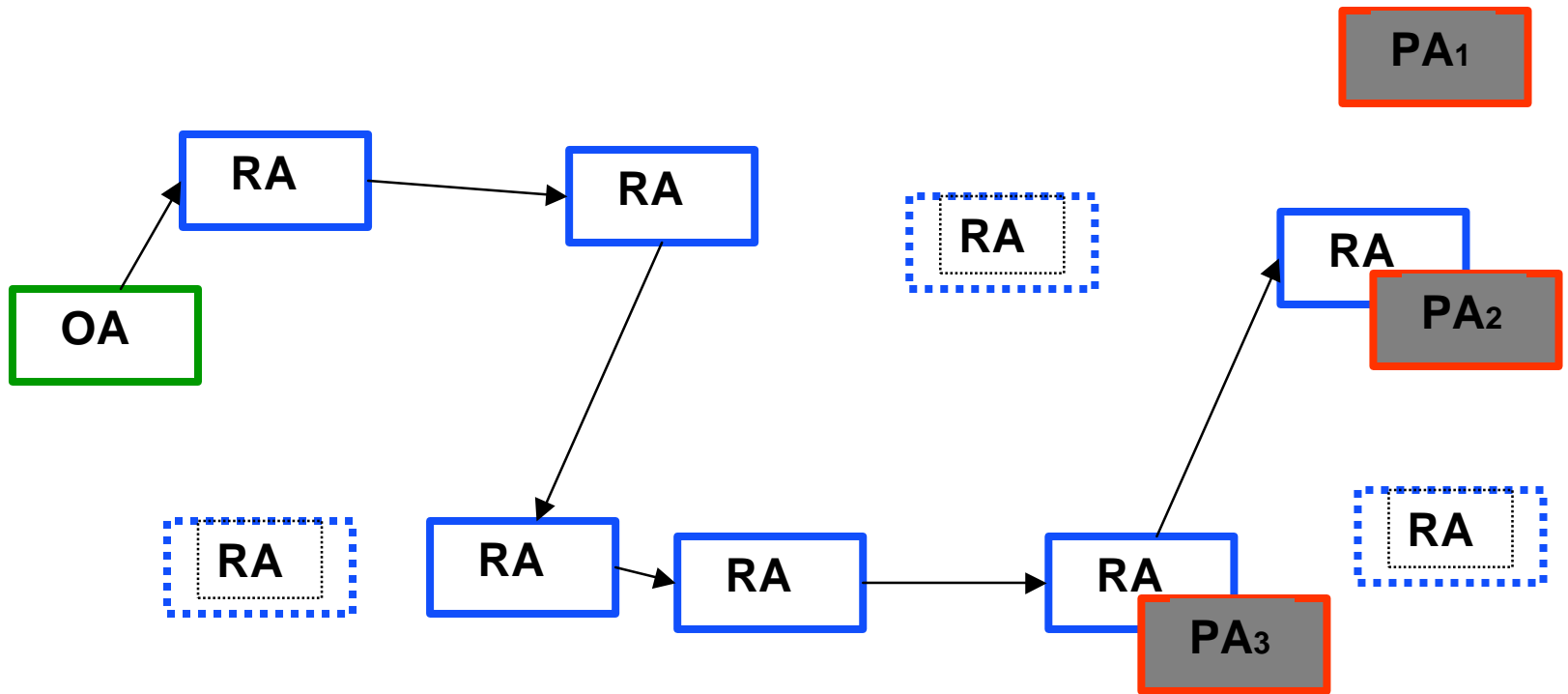


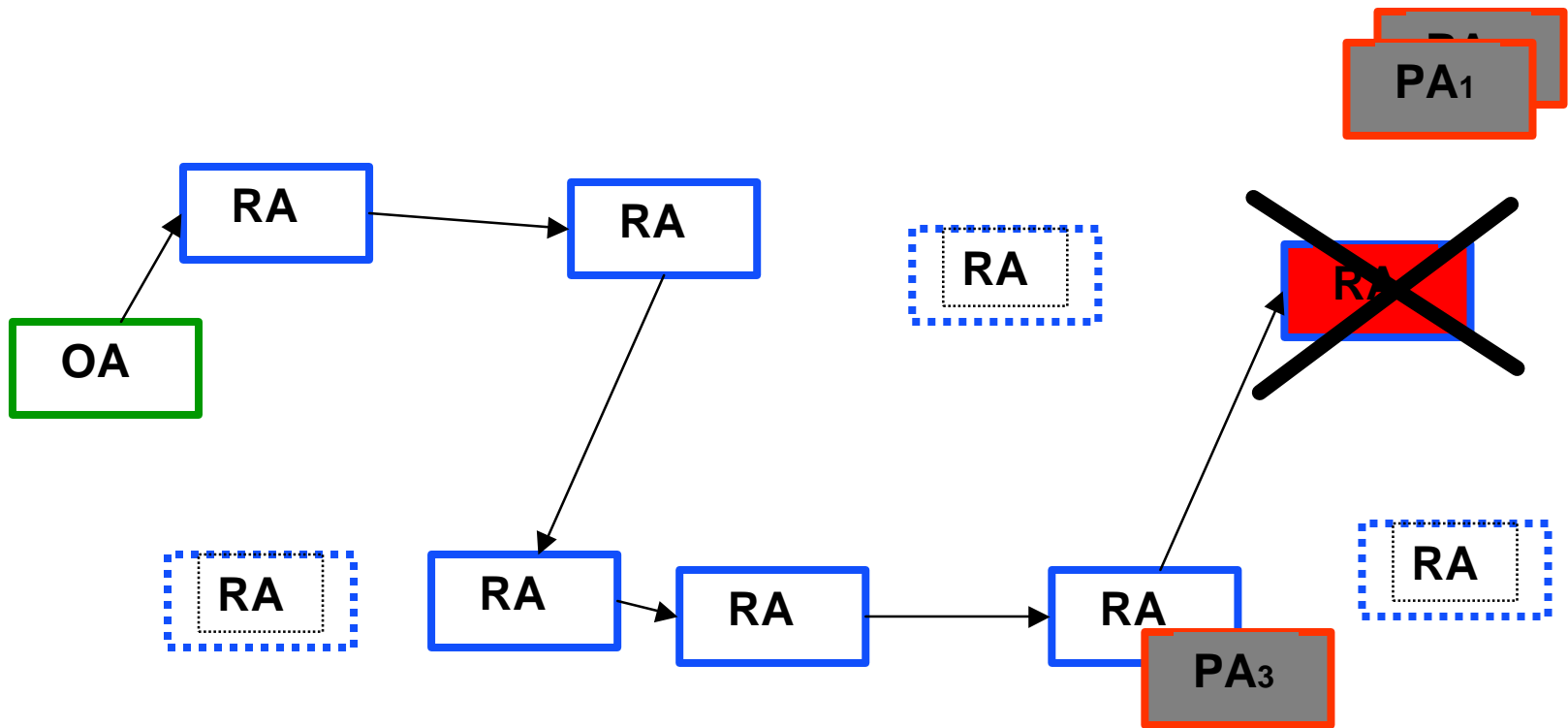
Order Driven Control Illustration



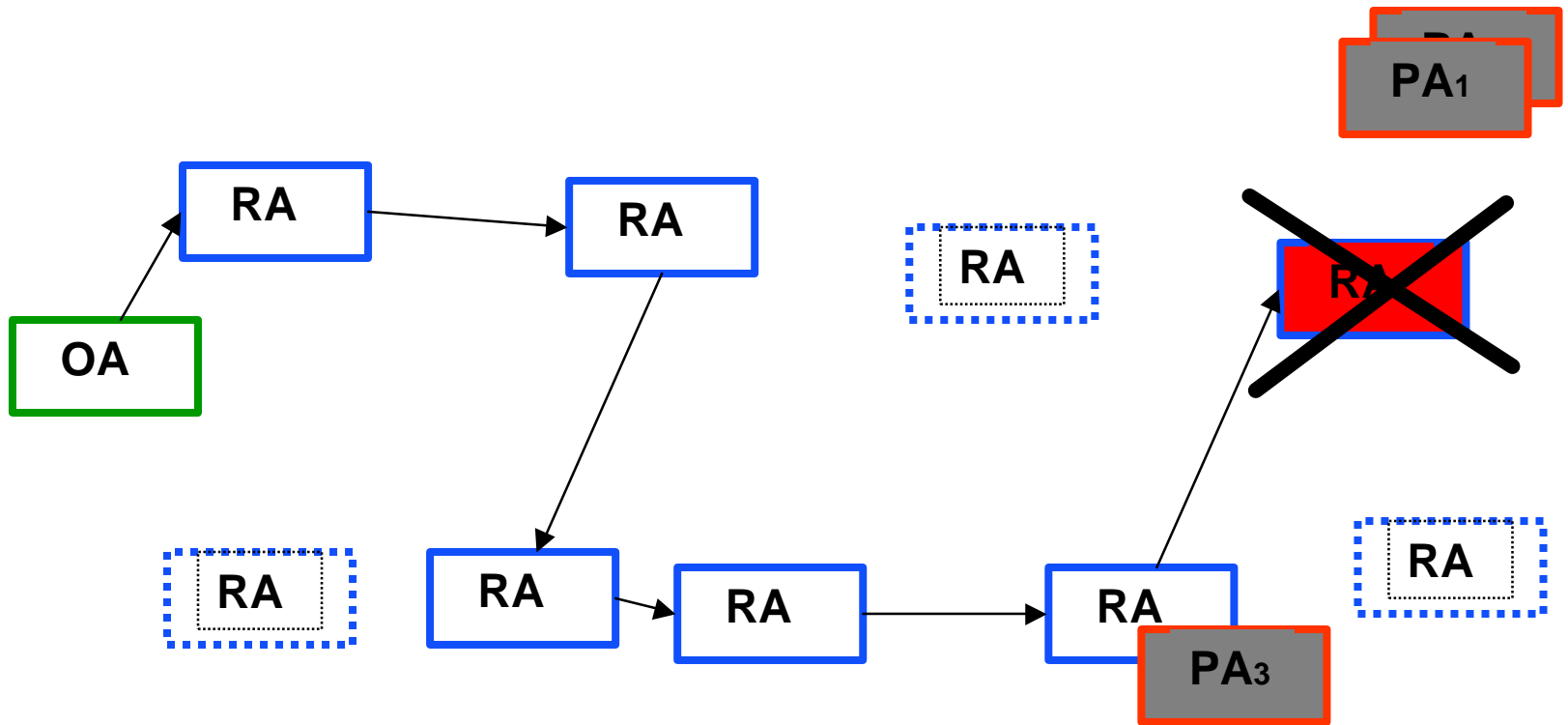
Example 2: Reconfiguration

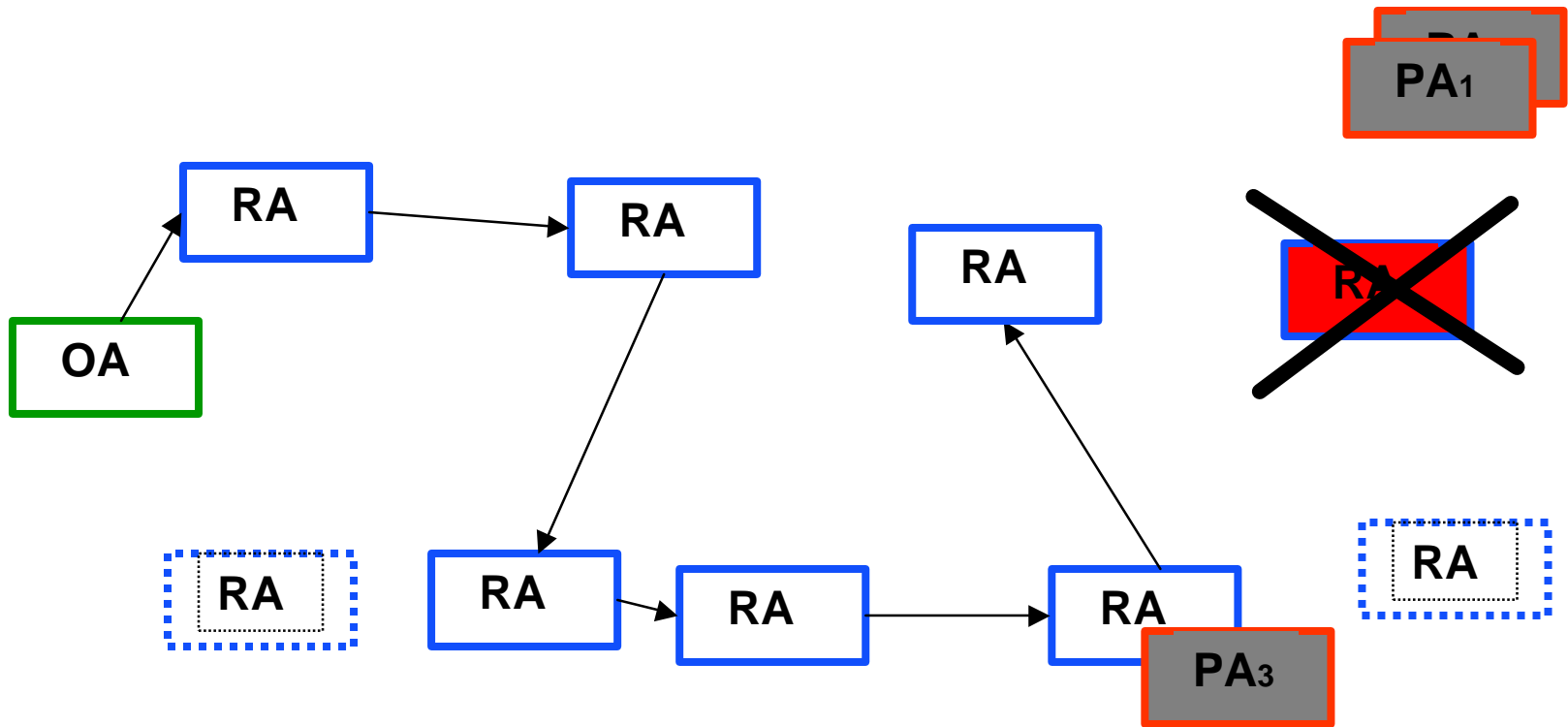


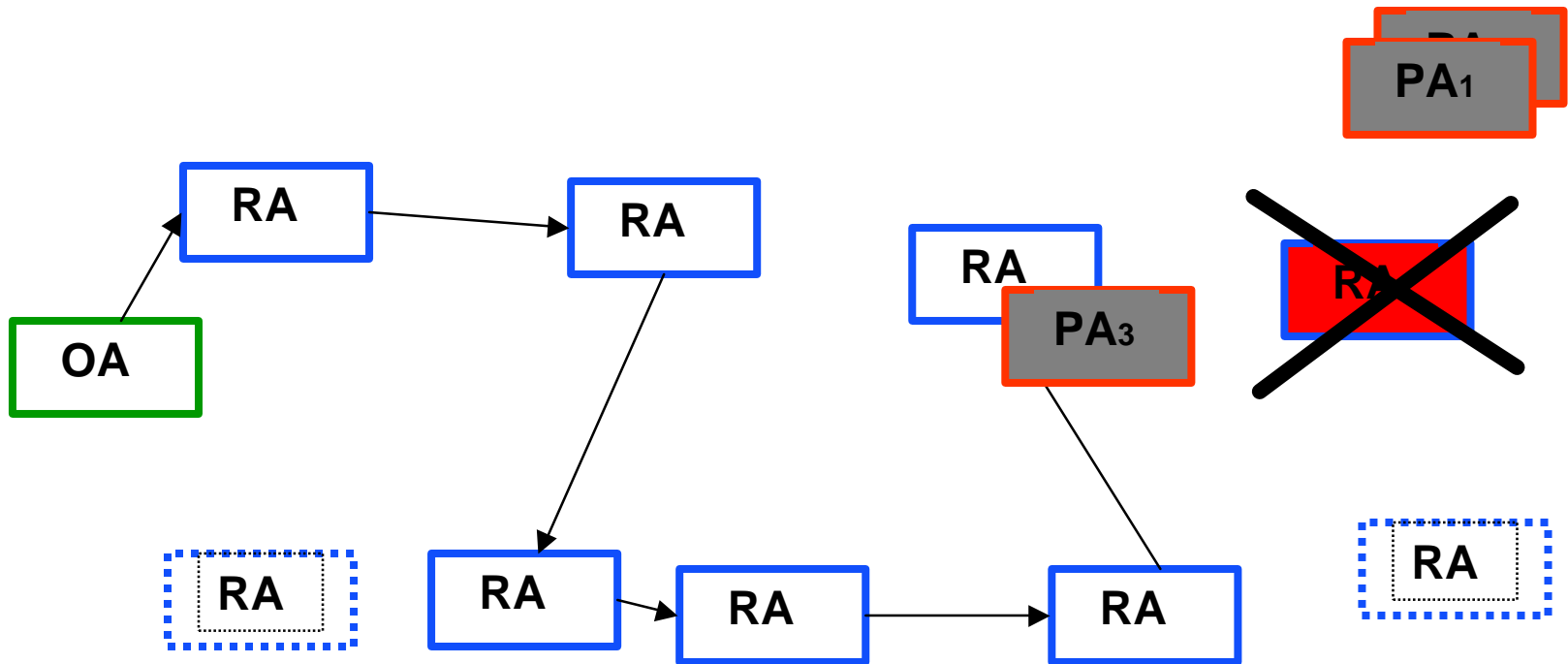


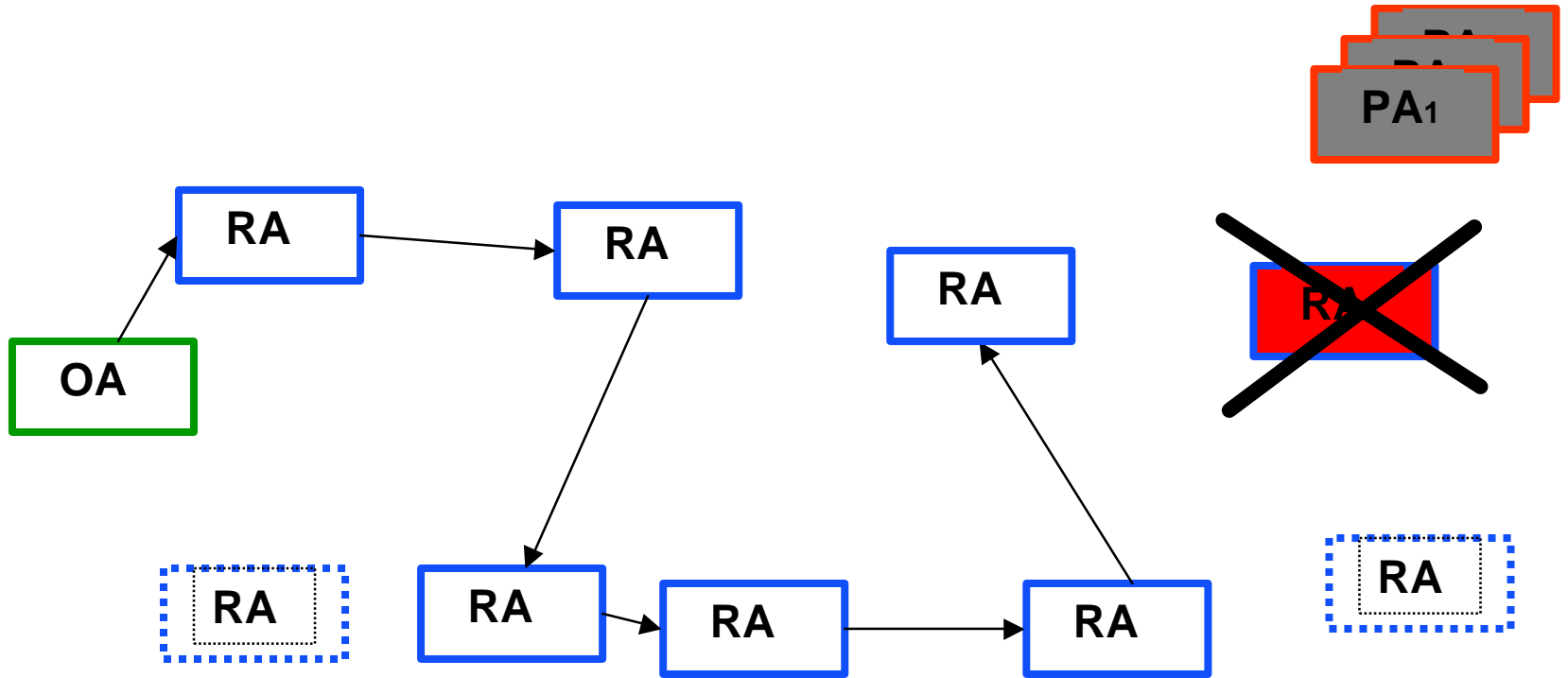


As PA3 is negotiating with the Resource Holders it reports that it is out of service.











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What is Being Done?

- Many years of research (15+)
- Serious prototype installations being built
- Vendors / Systems Integrators seeking to integrate agent capabilities into their products
- Agent based offerings becoming available from a number of SMEs
- End Users are seriously evaluating the benefits behind agents
- ... parallel developments in distributed computing, flexible communications, high fidelity sensing, flexible manufacturing



Towards Adoption

- systematic methodologies for repeatable developments
- increased emphasis on performance of agent based systems
- comprehensive set of standards
- adoption of agent concepts within industrial control system environments
- end user business cases considering future risk

