From Multi-Agent to Multi-Organization Systems

Utilizing Middleware Approaches

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Motivation: Software Systems in the Large

- Frequently referred to as
  - Application Landscapes
  - Ultra Large Scale (ULS) Systems
  - Software Cities
  - ▷ Characterization as large scale *Systems of Systems* (SoS)

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OrgOSE Hypothesis

There exists a strong analogy between modern software systems in the large and organizations in social societies. Thus, we need an organization-oriented approach to software engineering.

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MAS and the Organizational Metaphor

- Mechanism of *formalization* borrowed from social sciences

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  ▷ Rationality resides in an organization's structure itself
  ▷ Allows for separation of concerns in MAS engineering (organization vs. agent design)
  ▷ Formal organizational structure both *restricts* and *enables* organizational behaviour

Conceptions of Organizations and MAS

- ...a division of tasks, a distribution of roles, authority systems, communication systems, contribution-retribution systems...
  [Bernoux 1985]
- ...structured, patterned system of activity, knowledge, culture, memory, history and capabilities that are distinct from any single agent...
  [Gasser 2001]
- ...collective entity operating in a larger system of relations...
  [Scott 2003]

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Broadened Perspective Hypothesis

In order to exploit the true potential of the organizational metaphor, we need a broadened perspective that accounts for a systematic and disciplined treatment of collective levels of action in OrgOSE.

The ORGAN model: Purpose

1. Development of a universal comprehension of systems that can be differentiated for various levels of abstraction (of an SoS)

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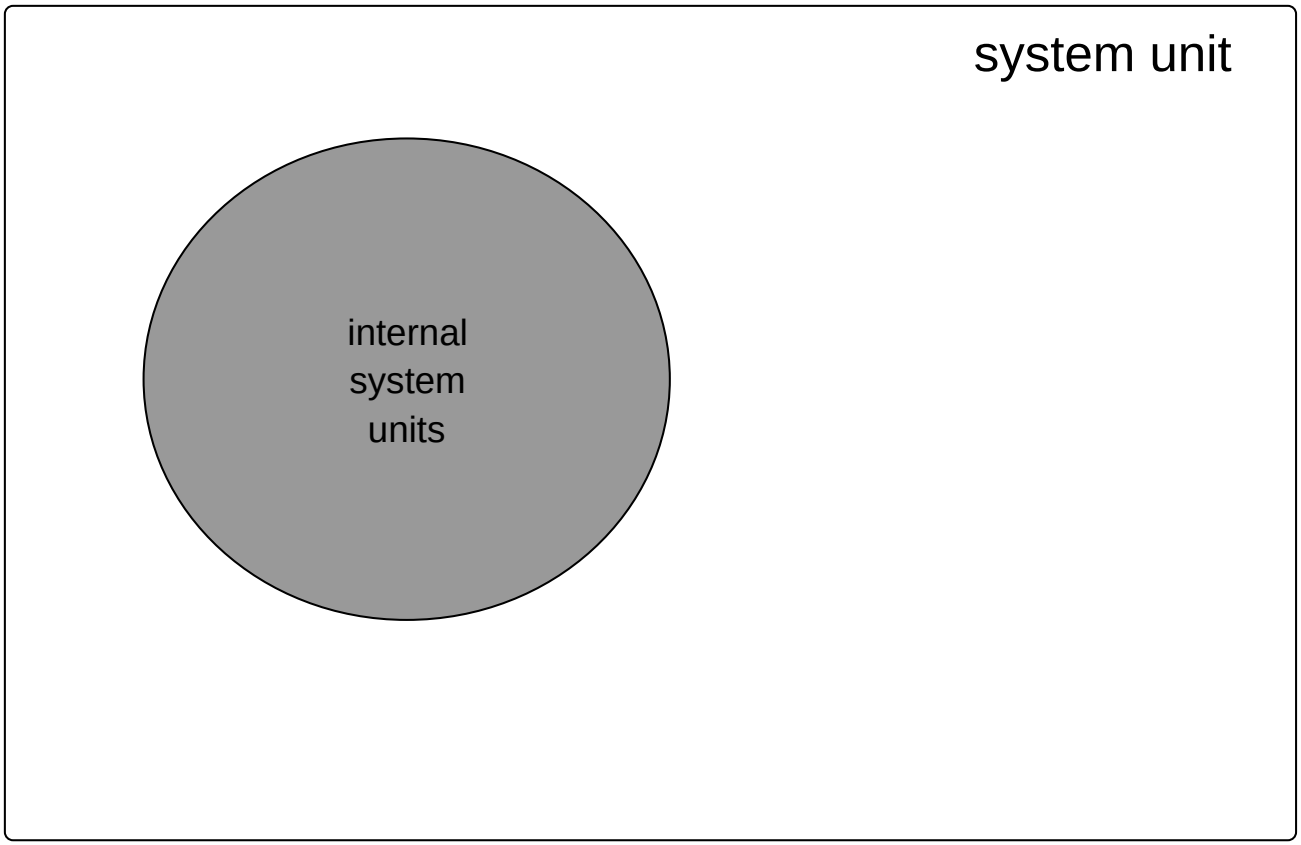
2. Development of a particular proposal for multi-organization systems (MOS) featuring specific types of system units

Modelling of Open and Controlled System Units



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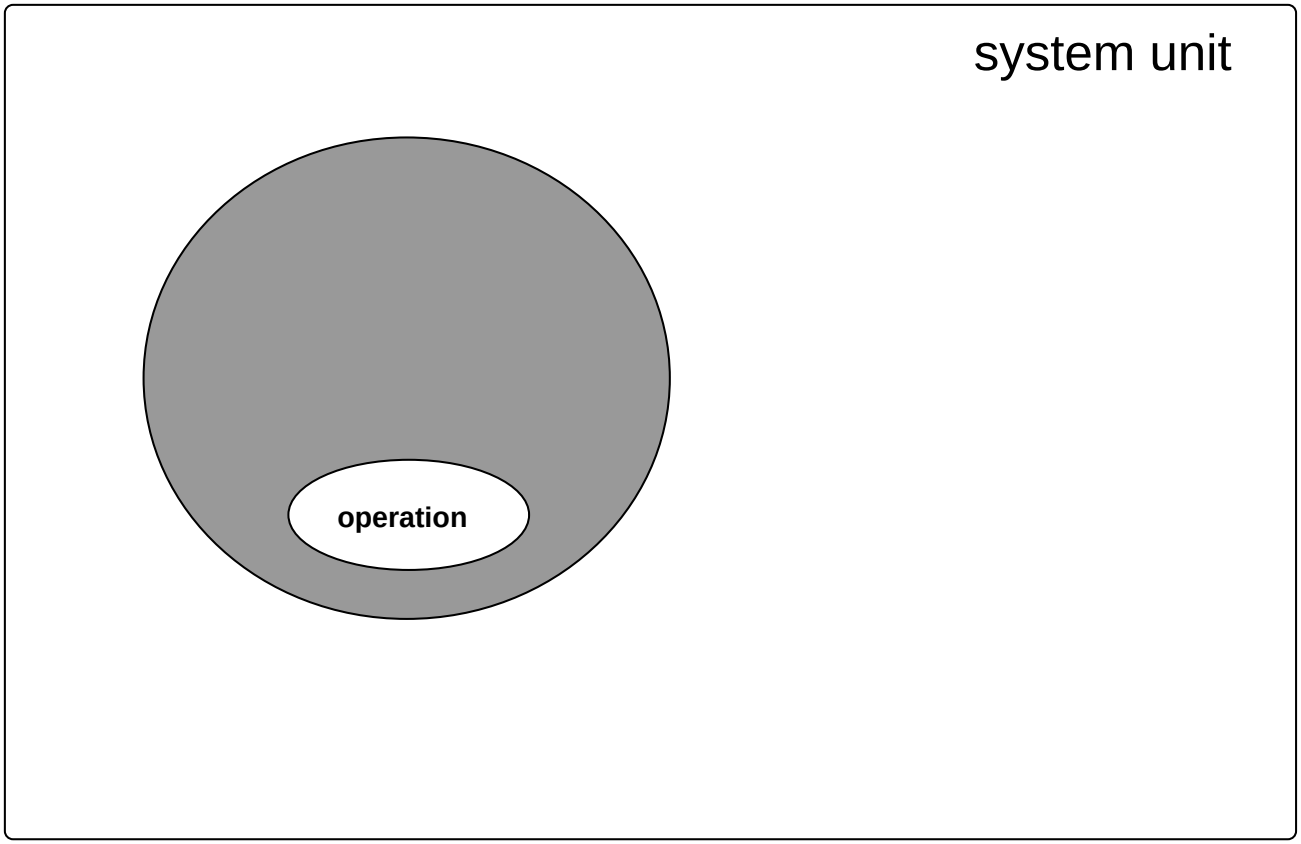

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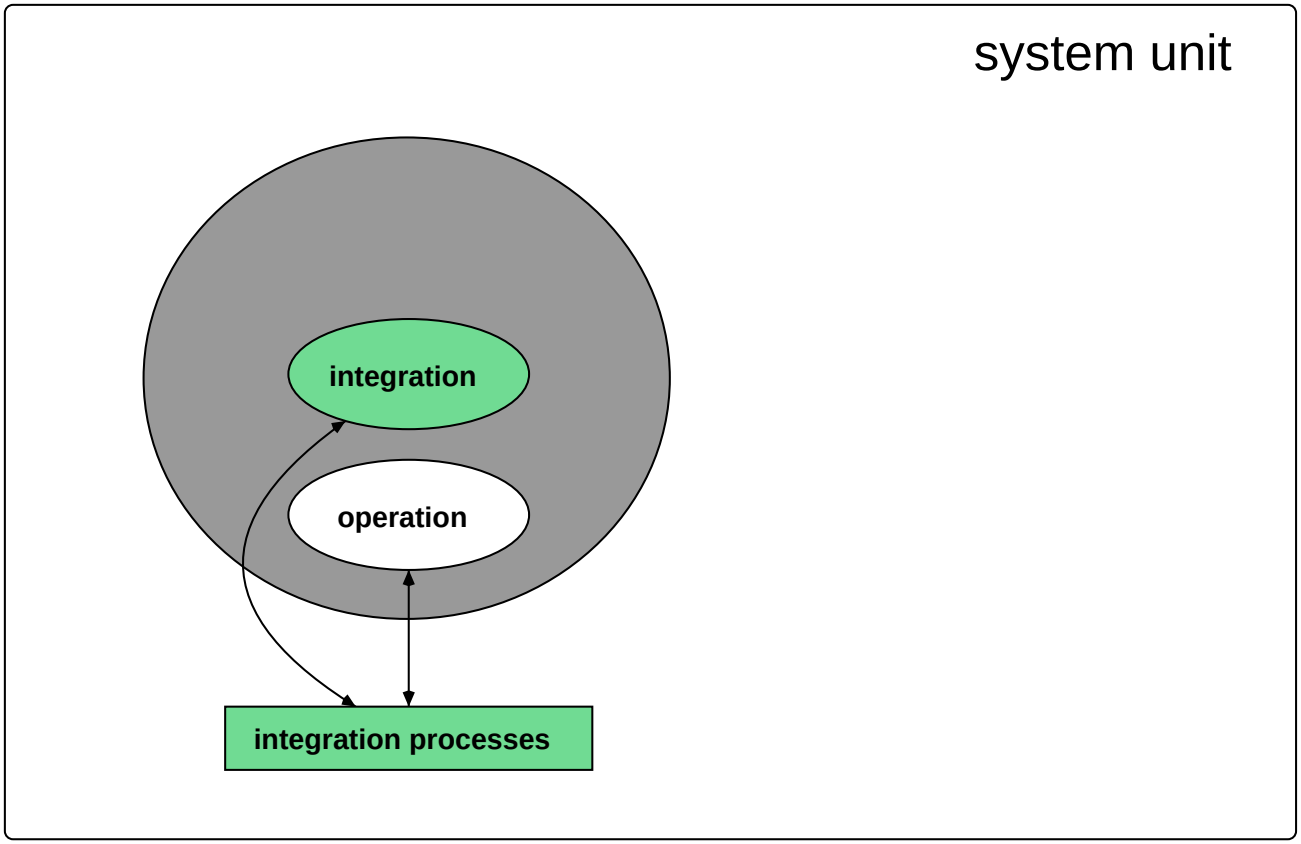

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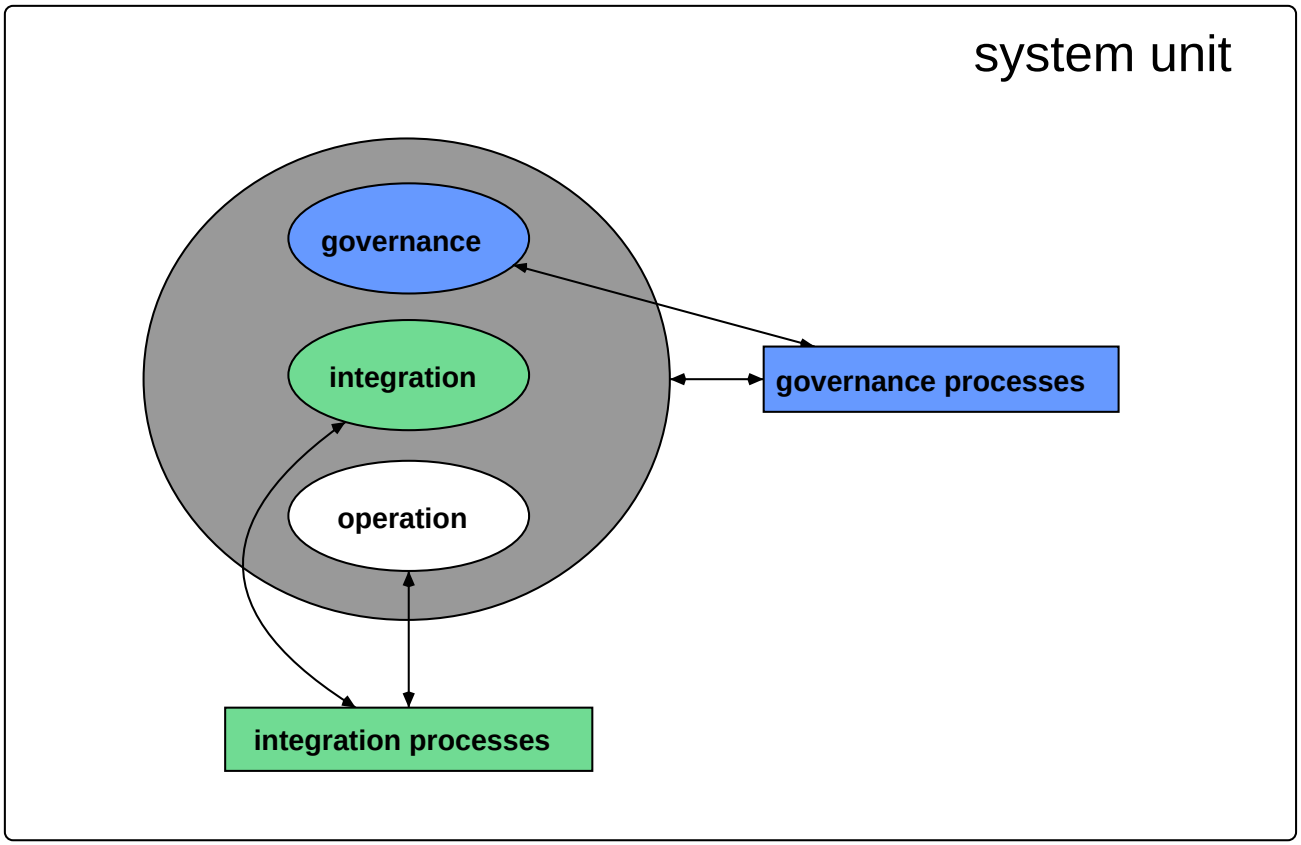

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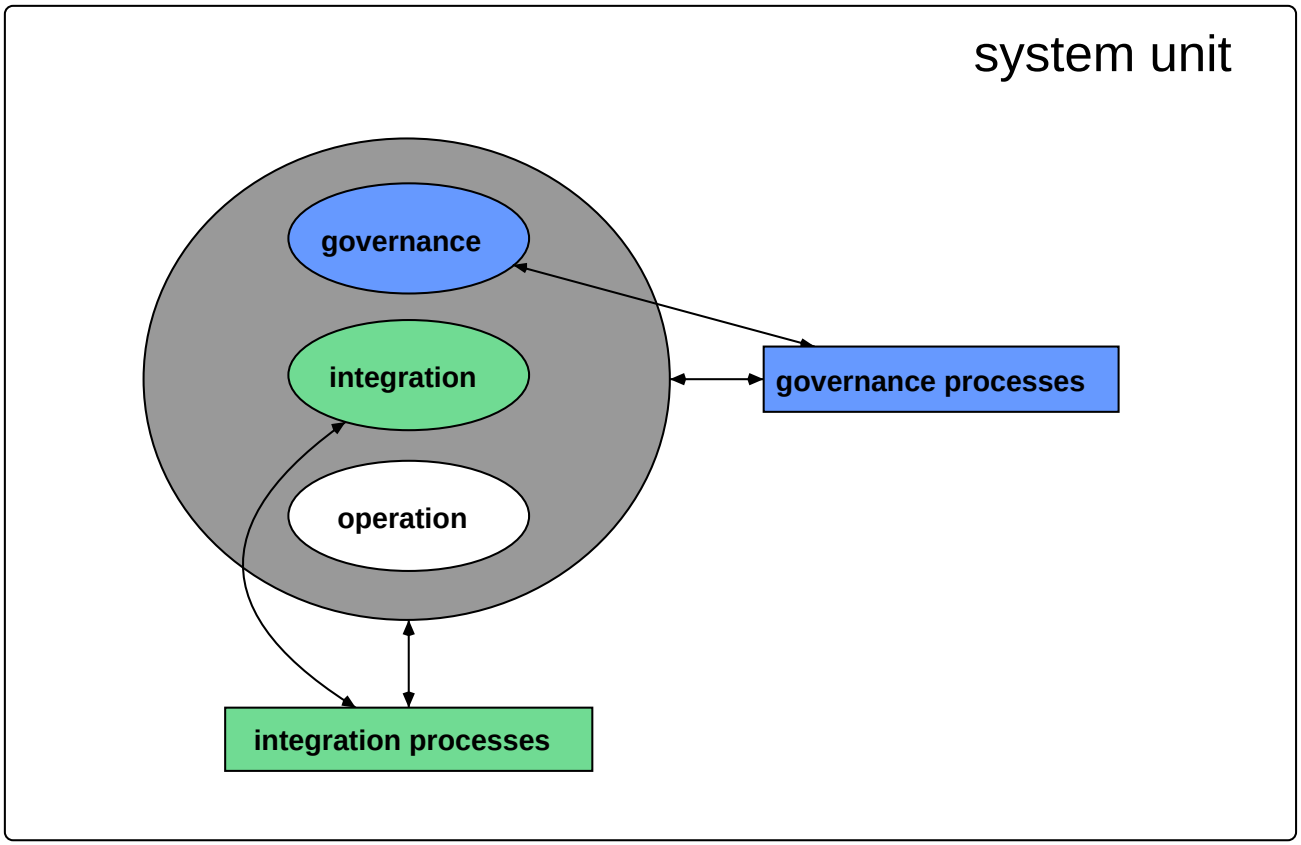

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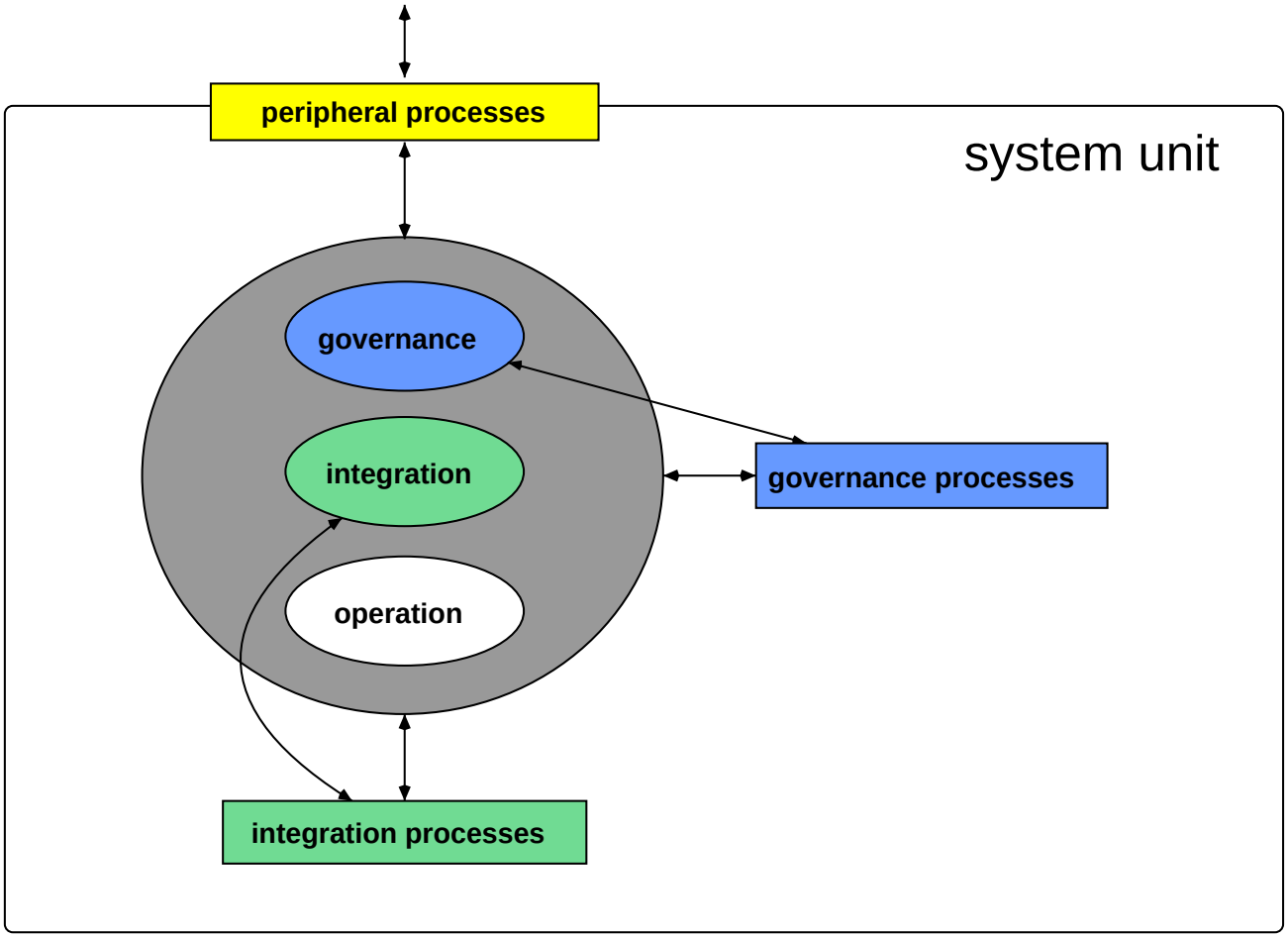

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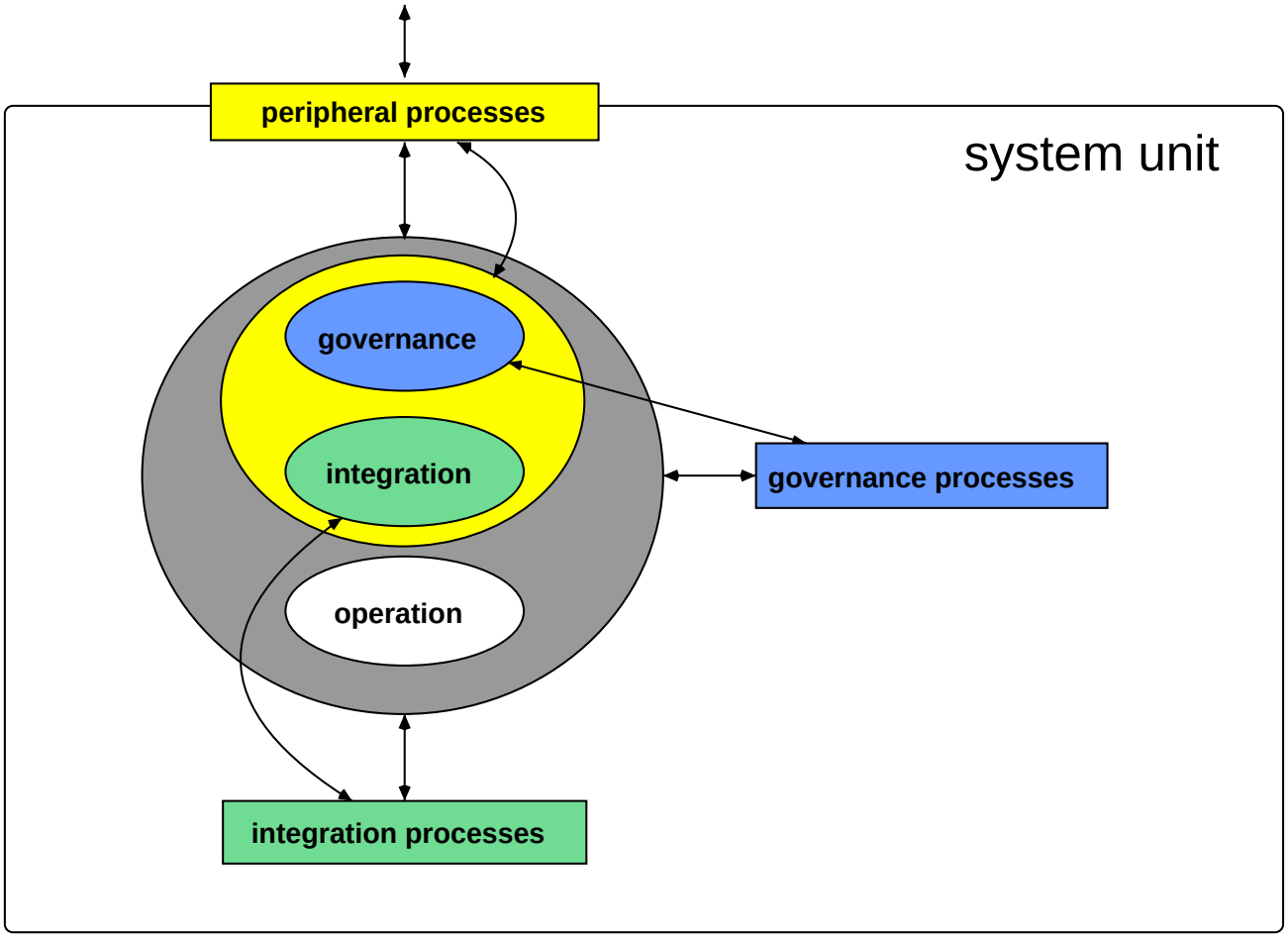

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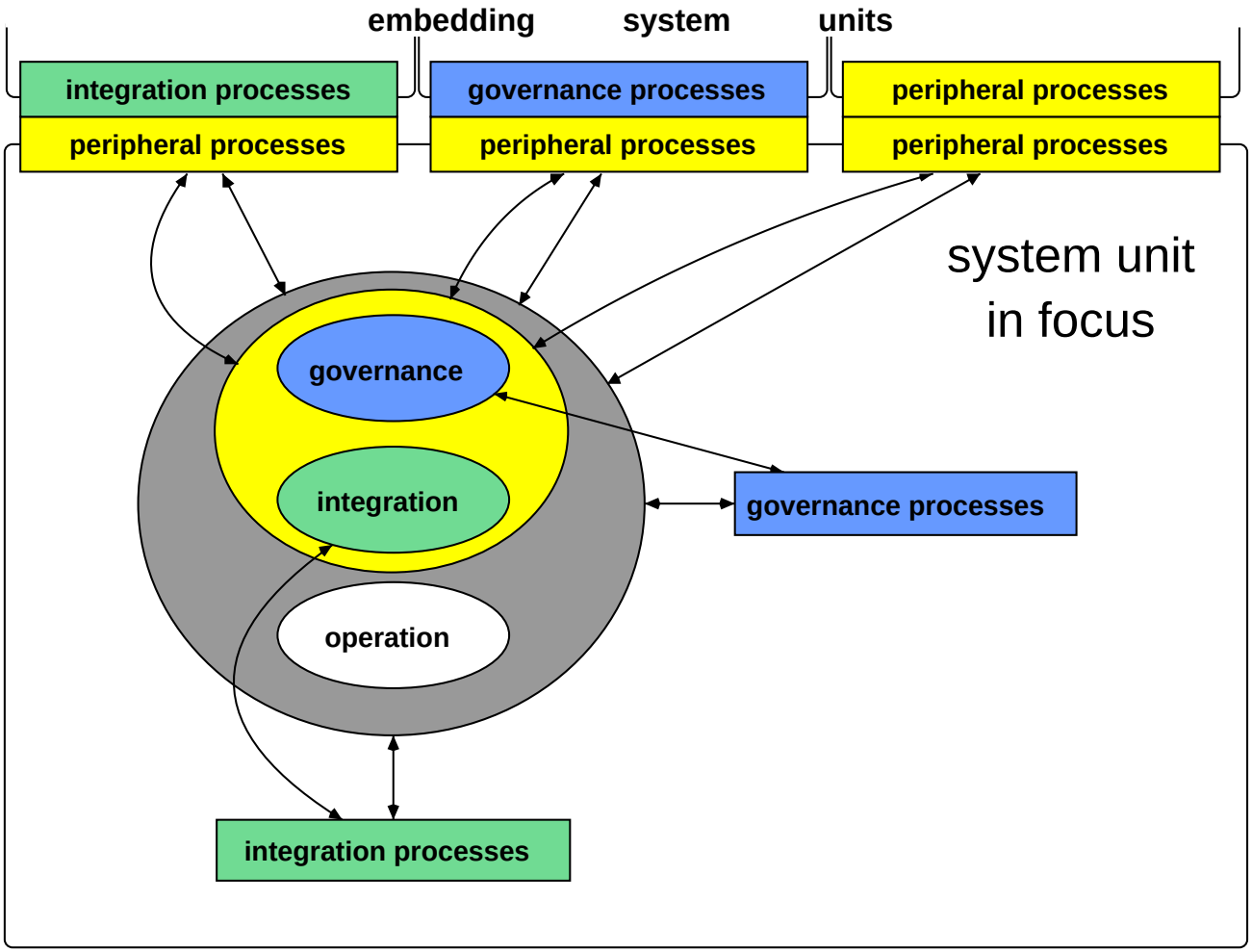

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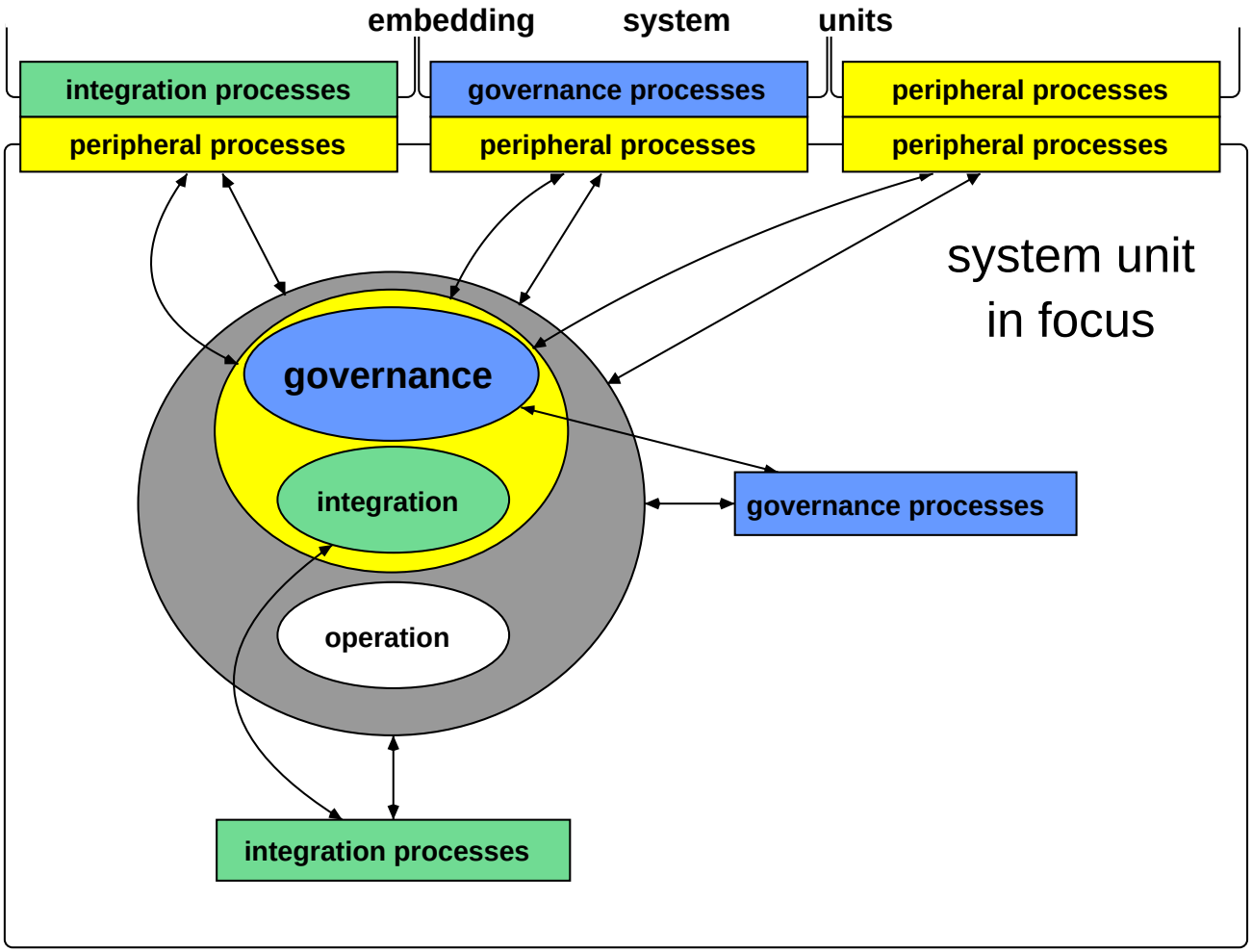

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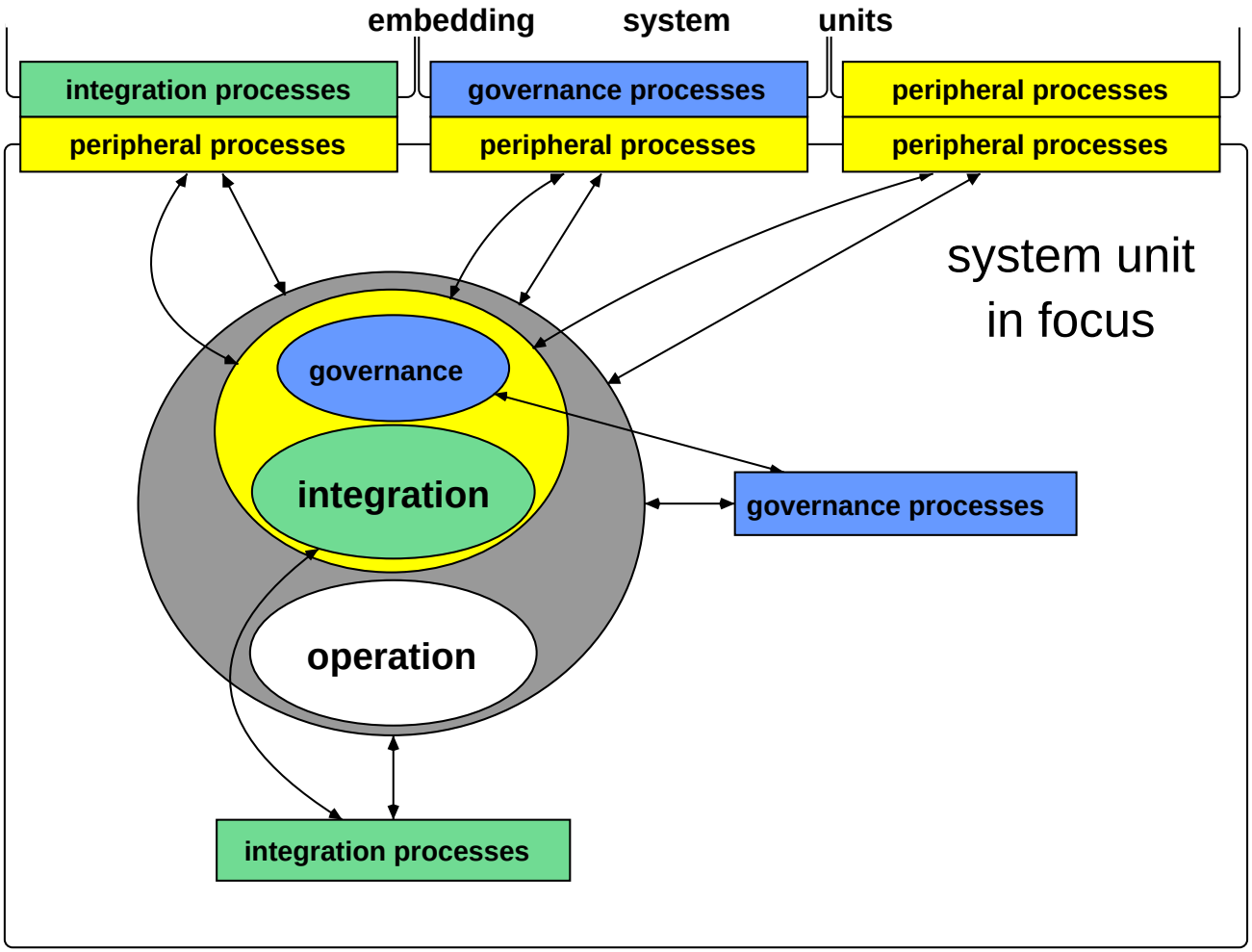
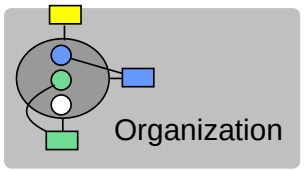


MOS Reference Architecture



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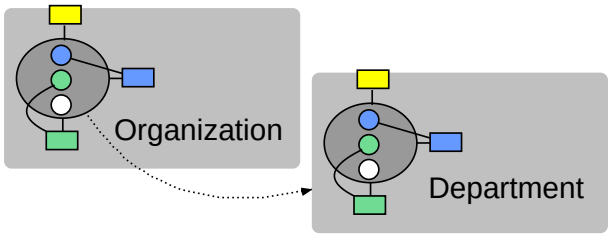

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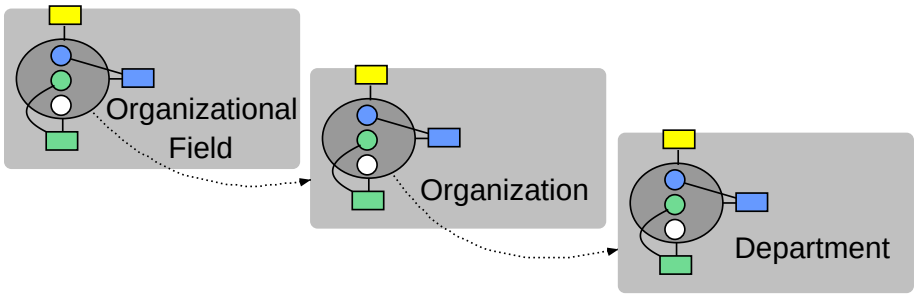

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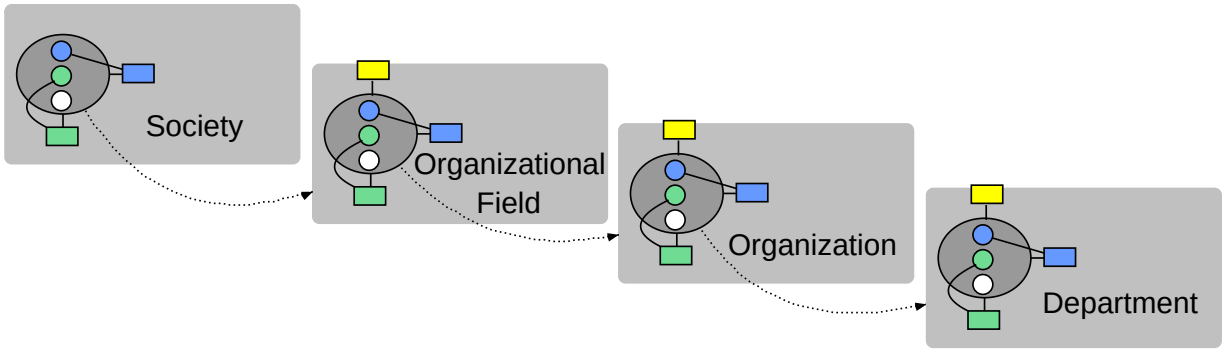

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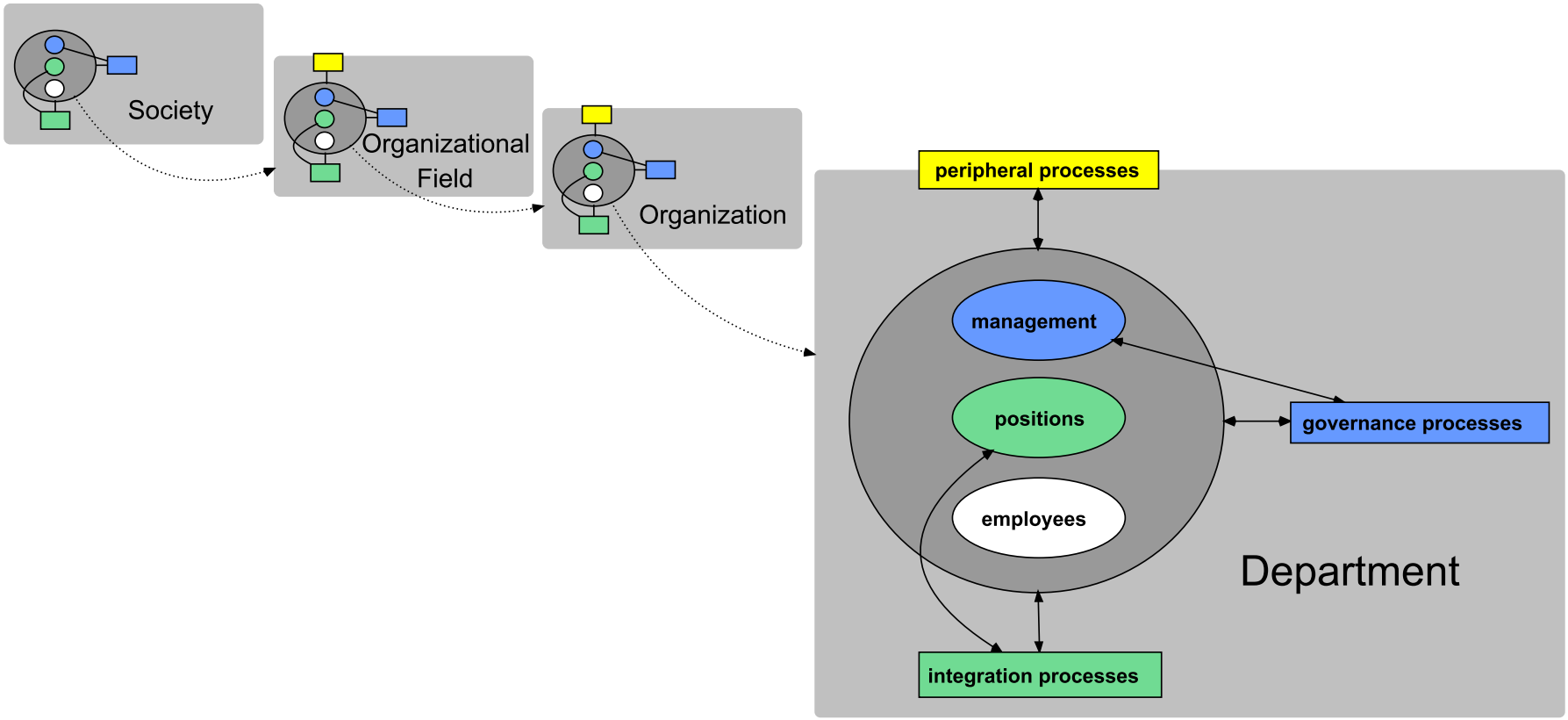

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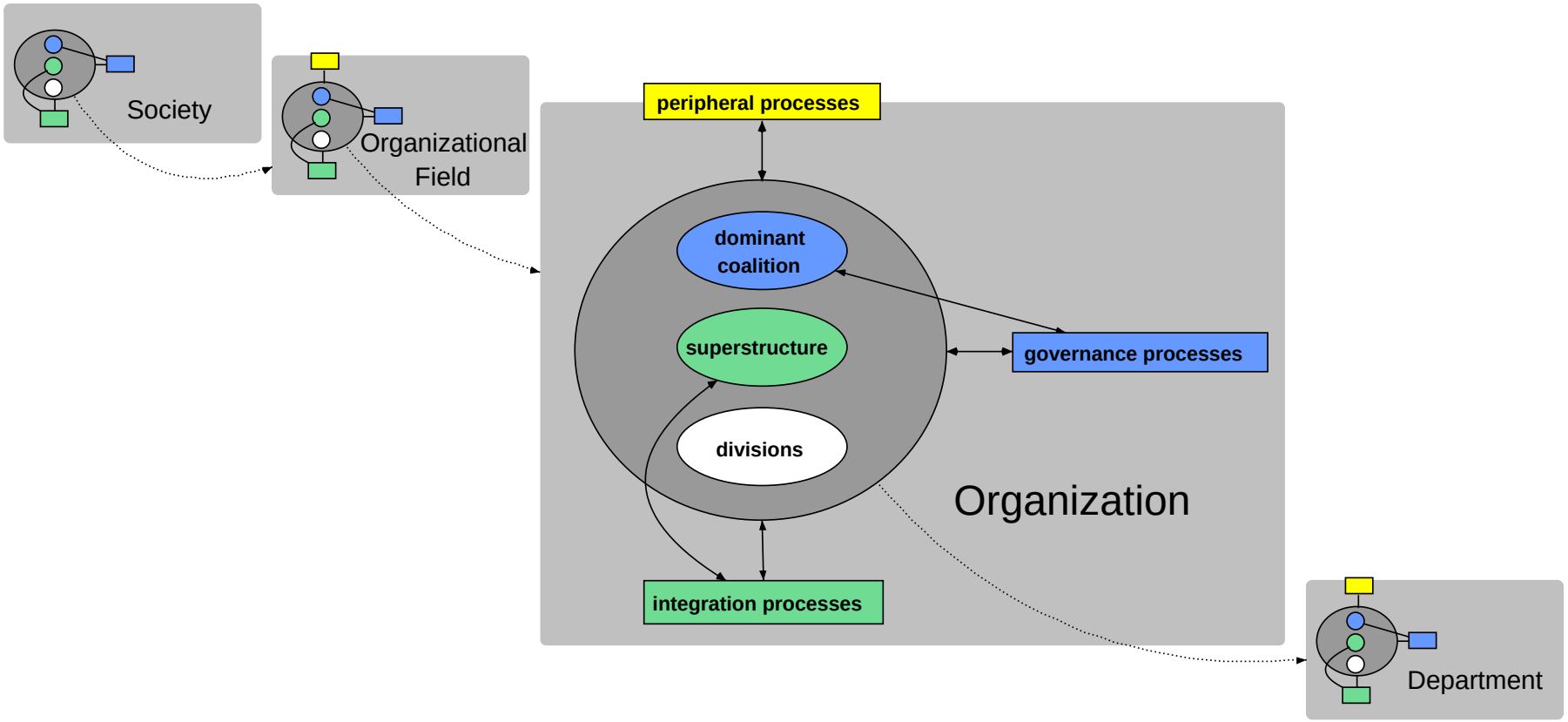

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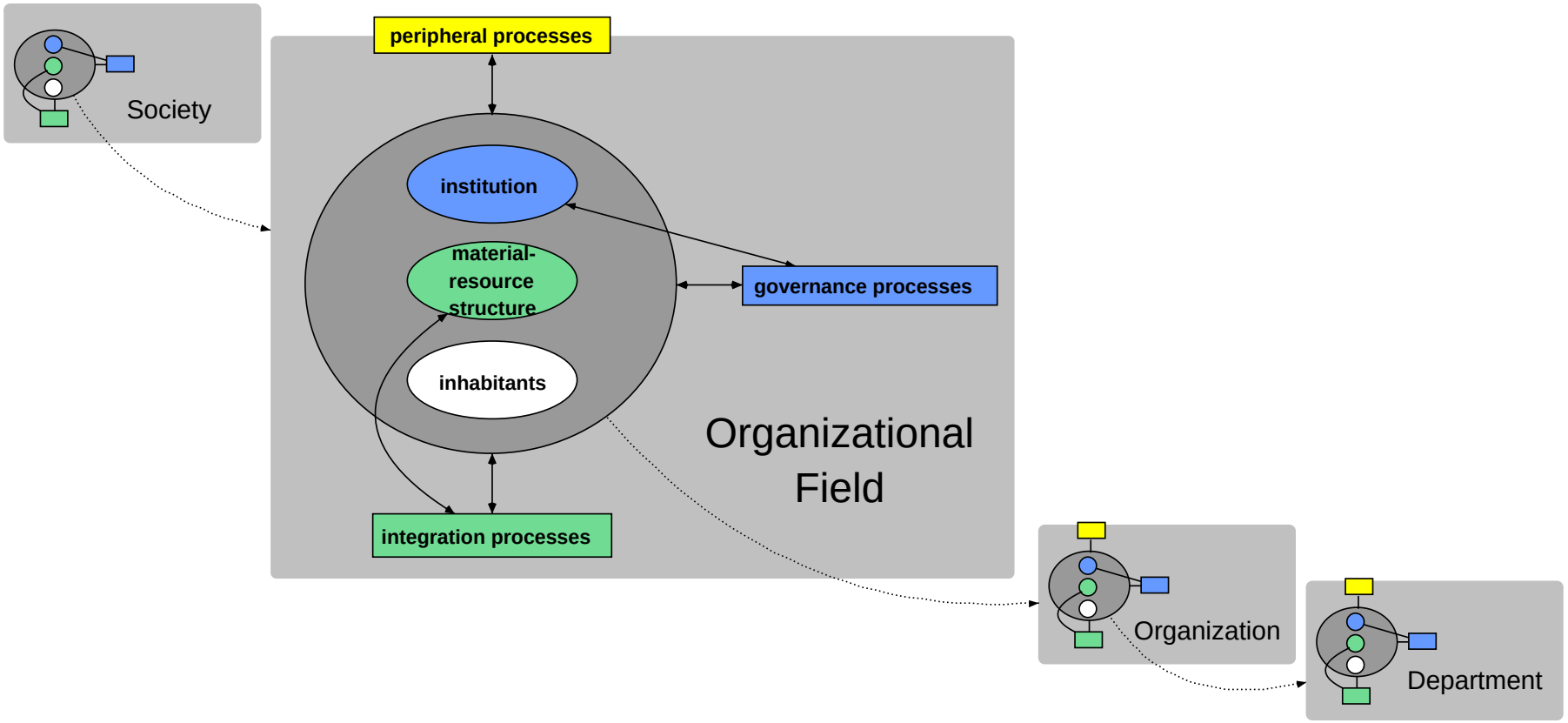

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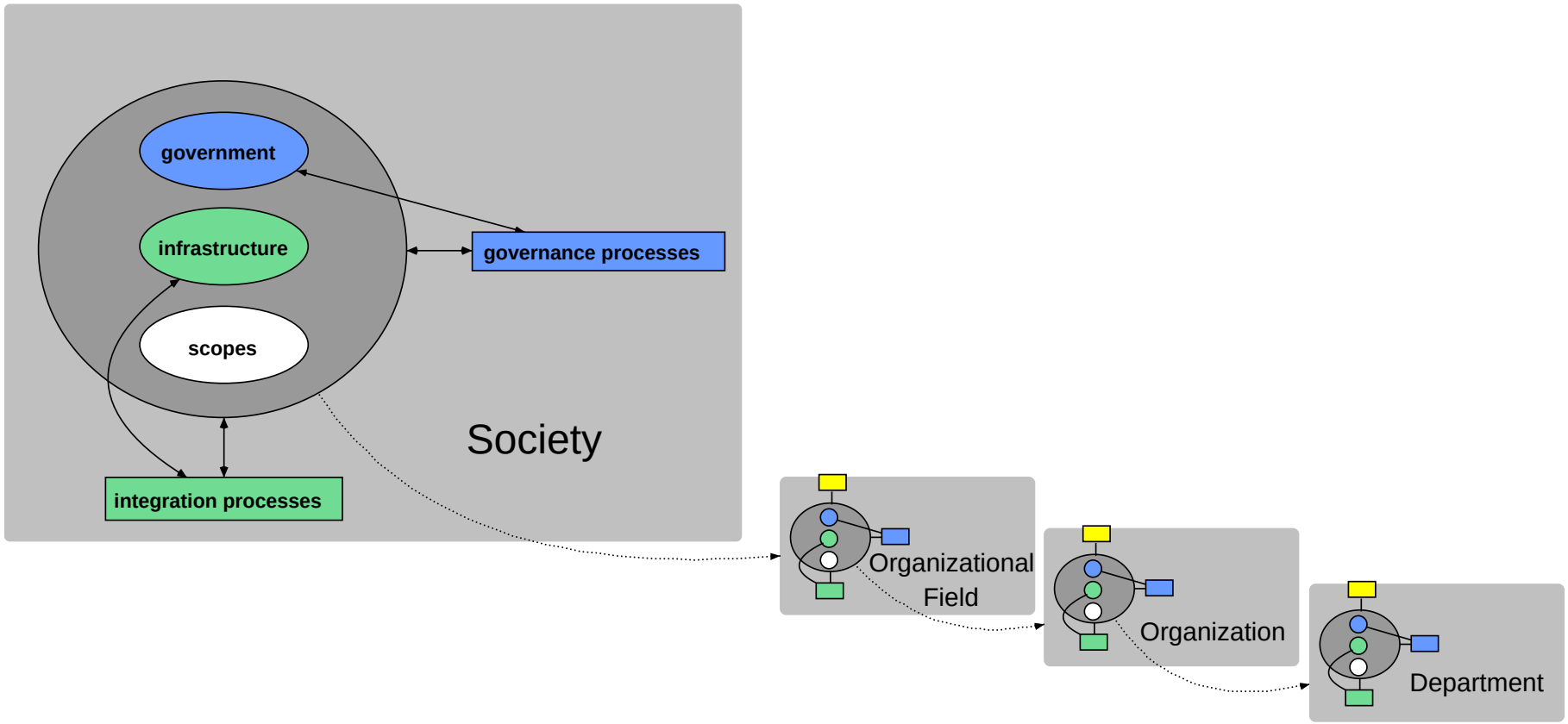
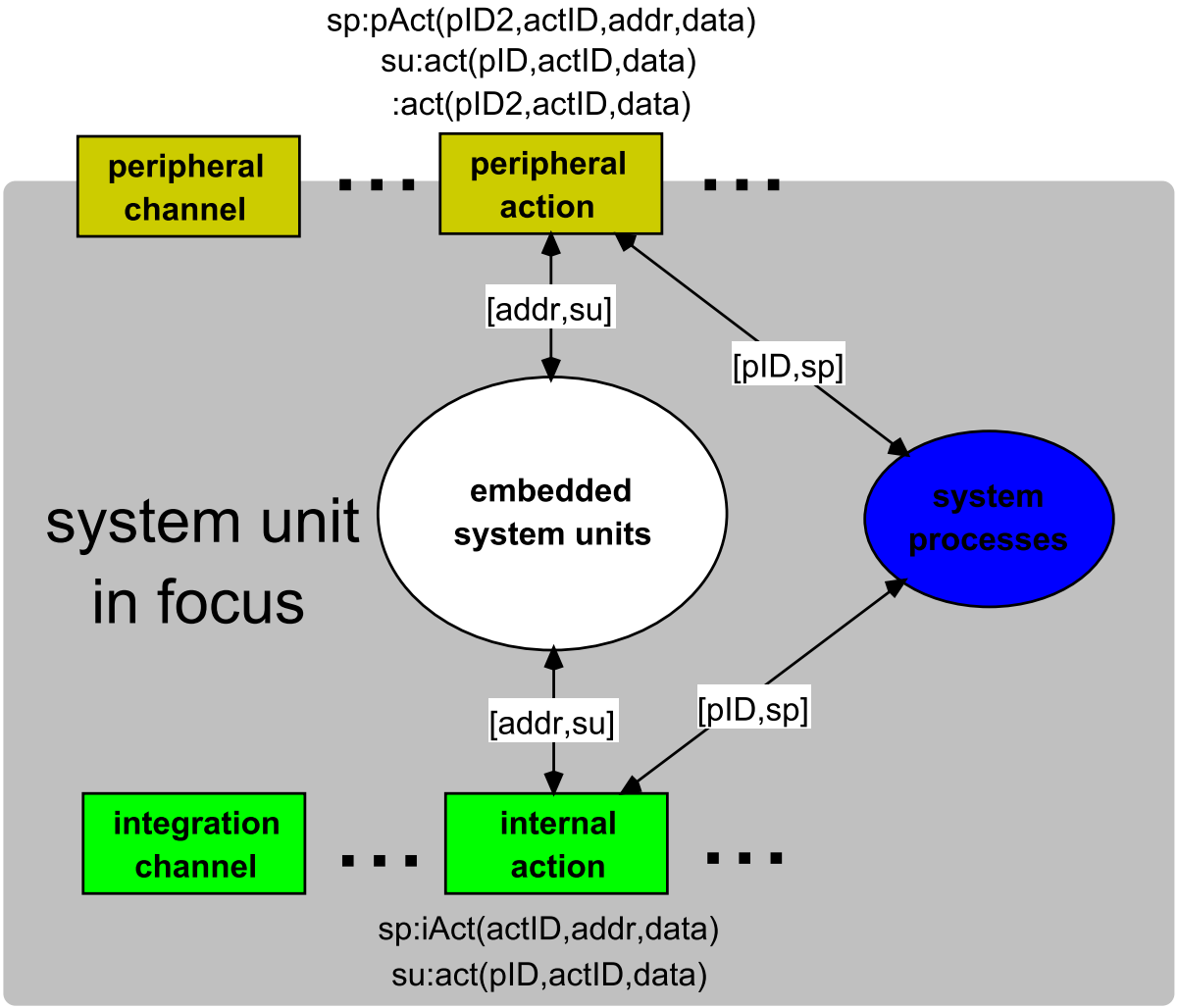


MOS Reference Architecture

ORGAN Hypothesis

The ORGAN model accounts for the true potential of the organizational metaphor.

Petri Net-Based Deployment



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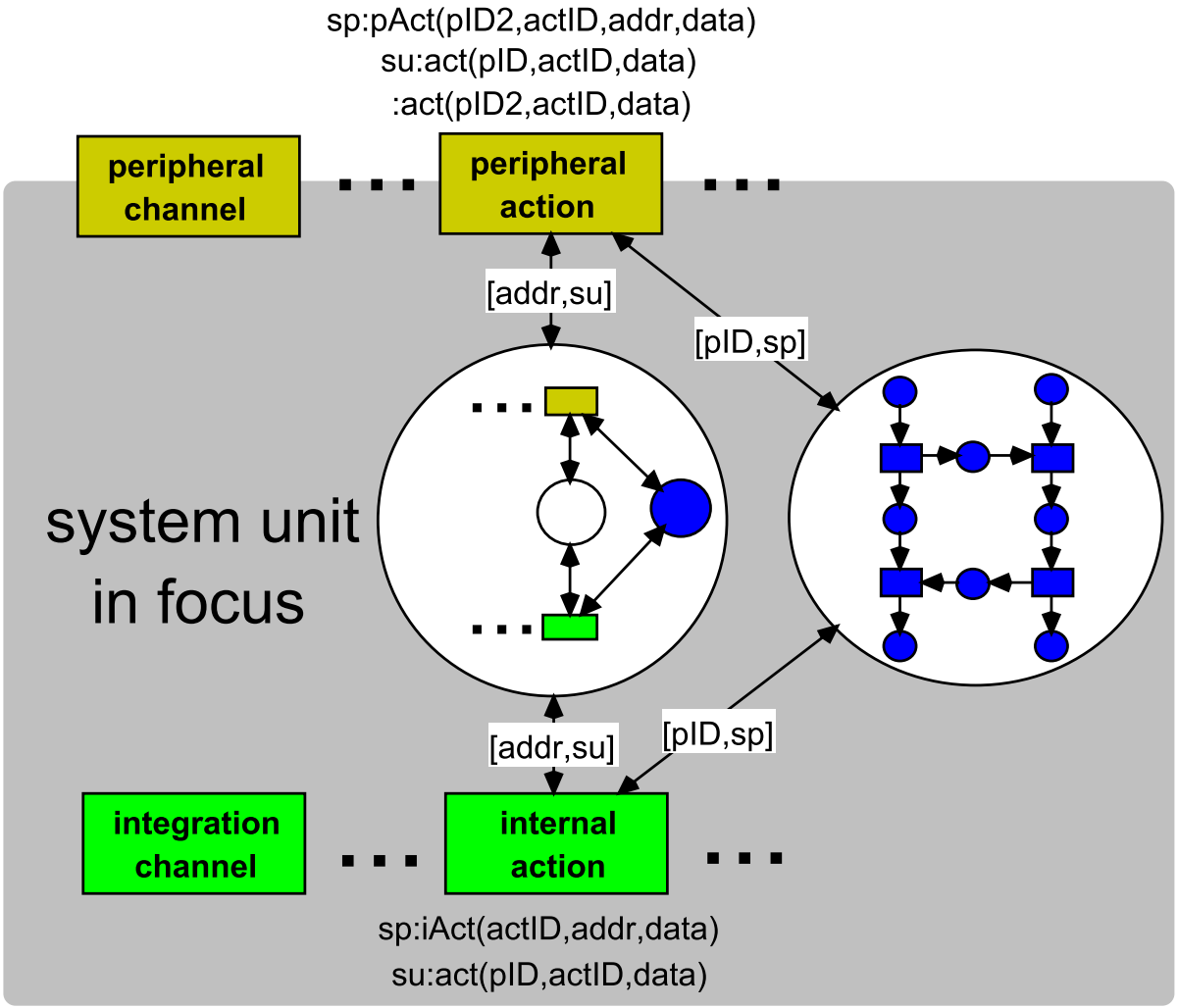
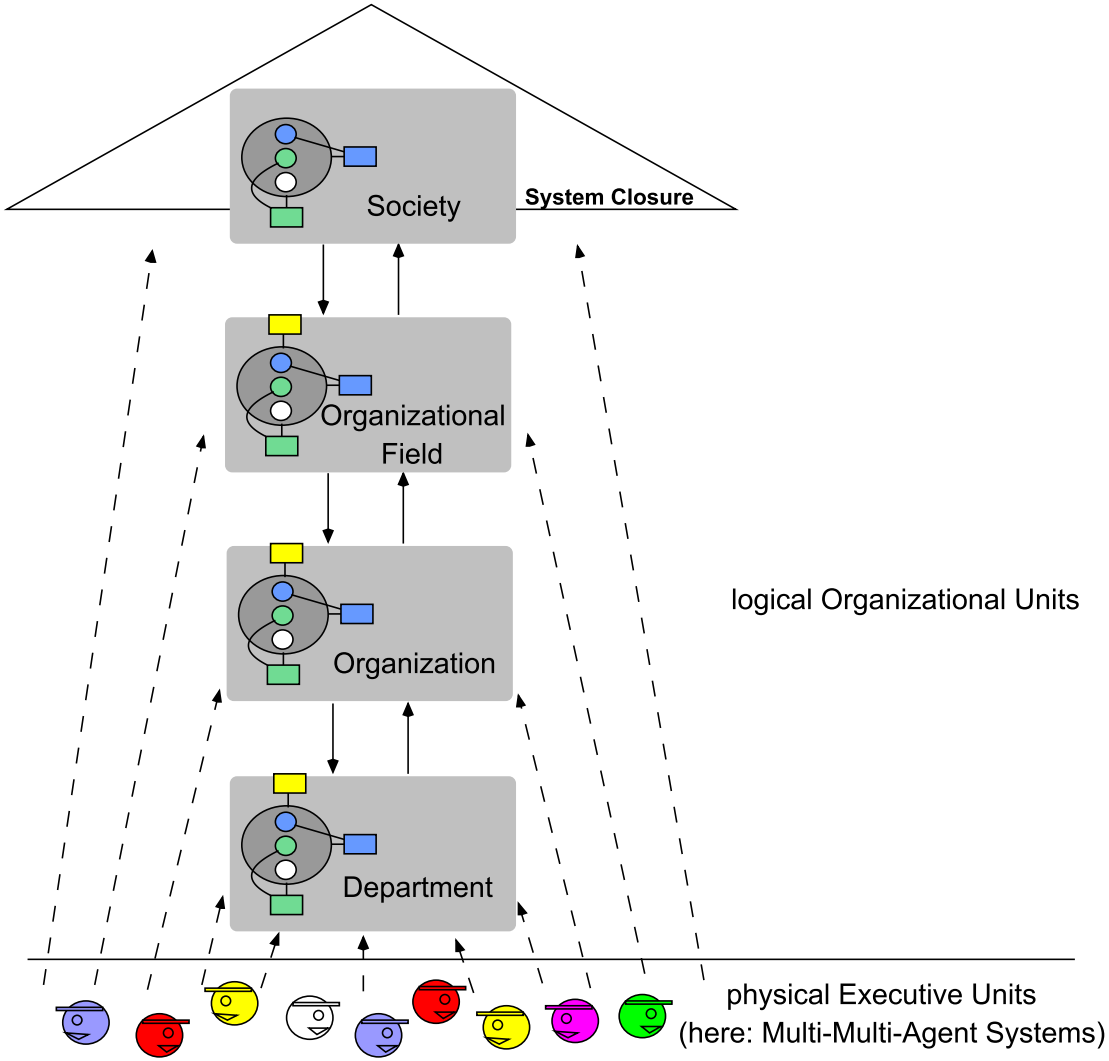


MAS Deployment



Utilizing Middleware Approaches (1)

- Middleware Approaches carry the principle of "separation of concerns" introduced by formalization to the software level
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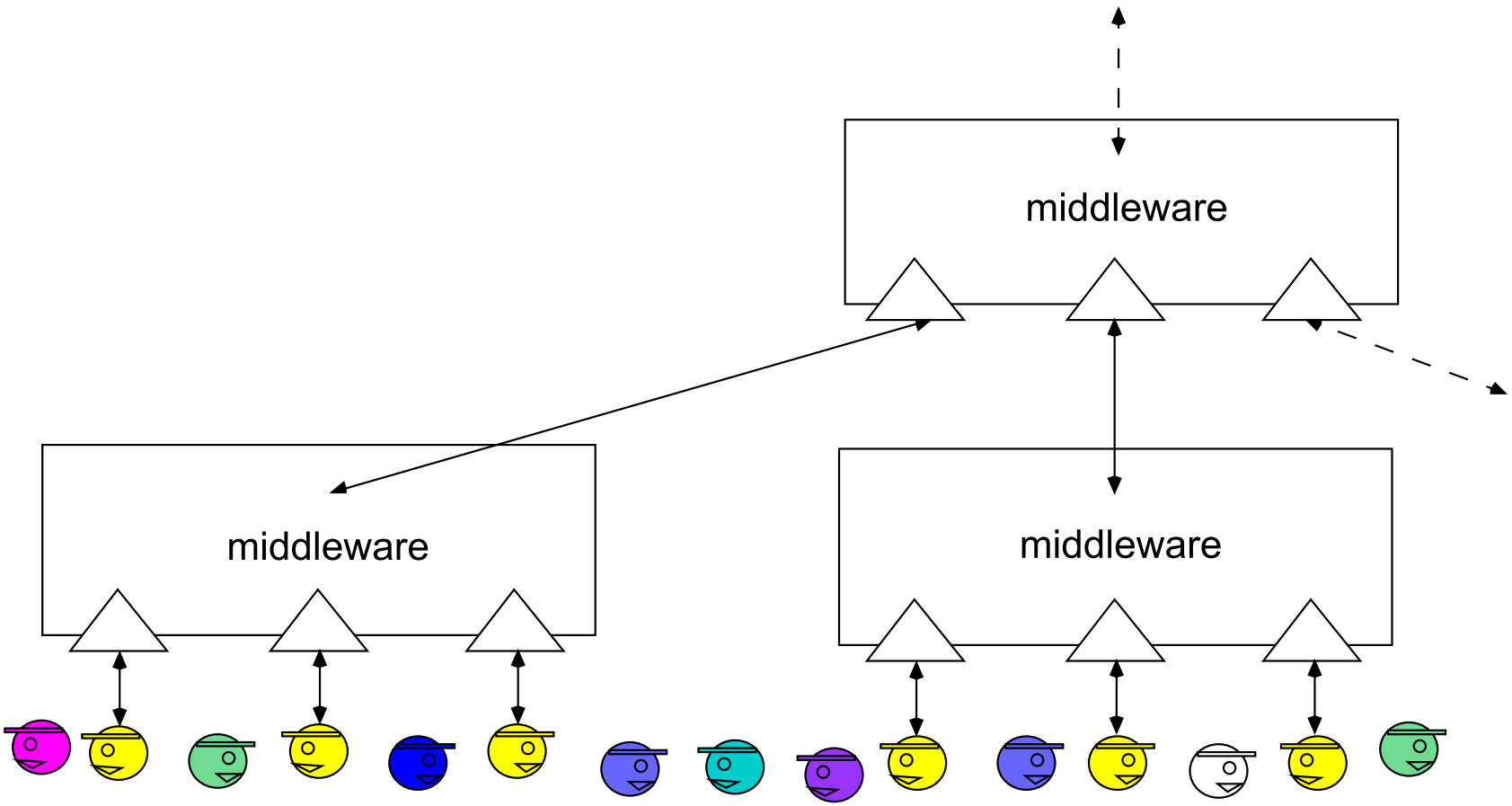
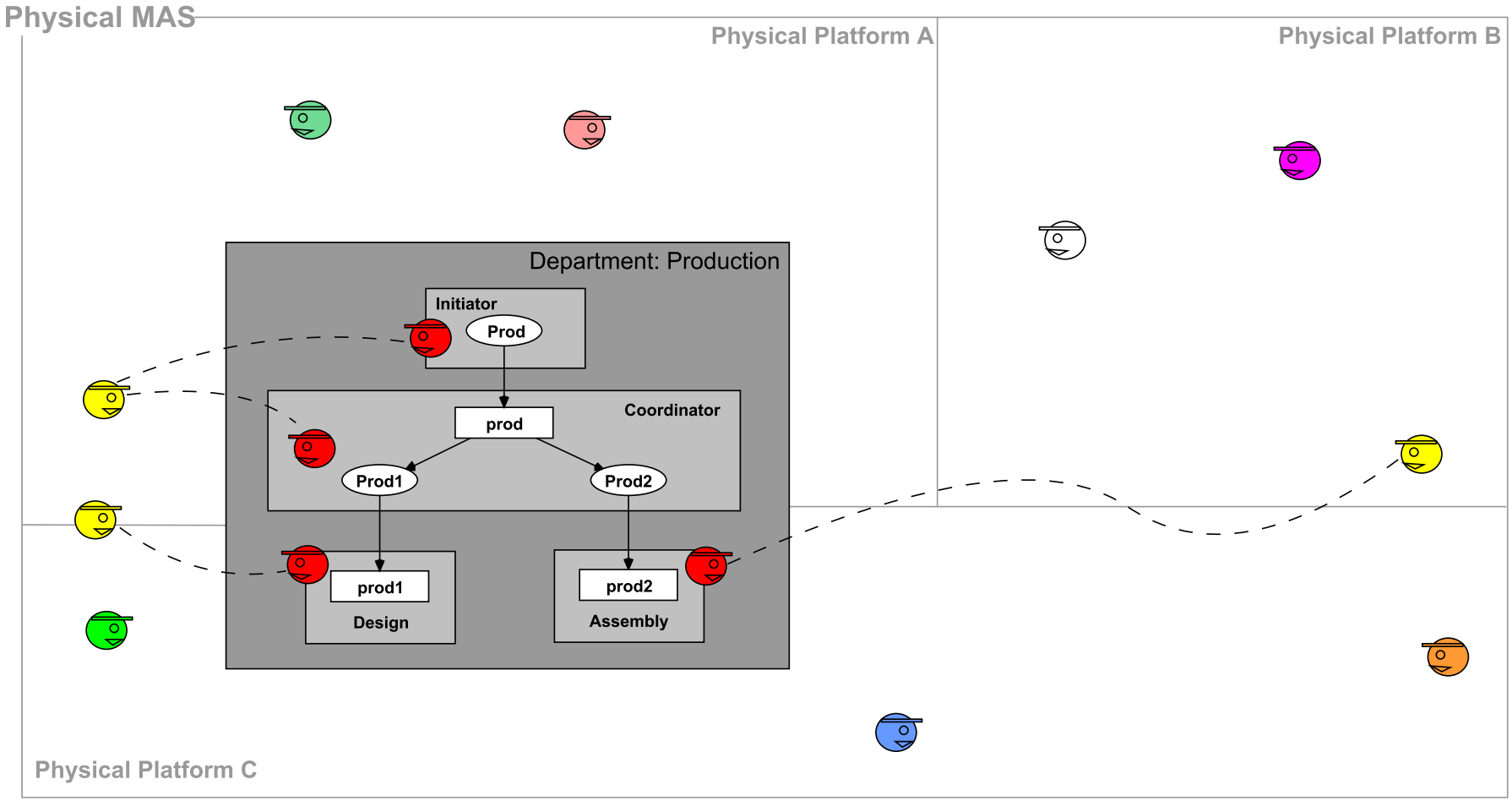
Nested Middleware Layers Hypothesis

The "agent neutrality" of middleware approaches can be carried forward to the modular engineering of different levels of SoS.

Utilizing Middleware Approaches (2)



Nested Layers - Example Sonar



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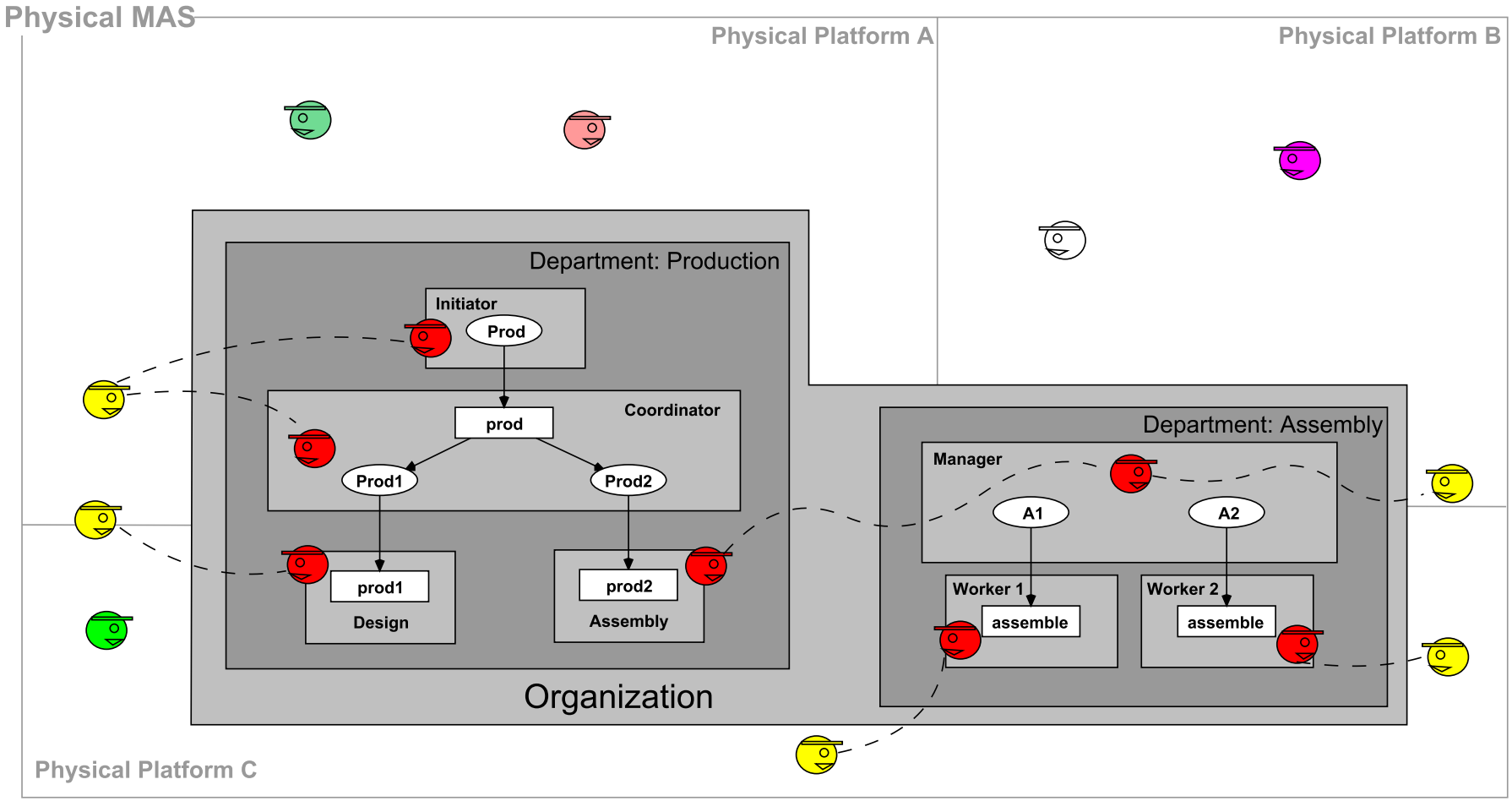

Pooling of Competencies

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We may avail ourselves of the broad spectrum of already existing organizational MAS approaches in order to establish a "best fit" between different approaches and different levels of SoS.

Pooling of Competencies: To Be Discussed

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- "First guess" proposal for systems according to ORGAN
  - **Department level:** $\mathcal{M}$OISE$^+$/$\mathcal{S}$-$\mathcal{M}$OISE$^+$ (constructive, fine-grained *role* relationships, centralized middleware management)
  - **Organization level:** SONAR (constructive, high-level *position* relationships, distributed middleware management)
  - **Organizational field and society level:** ISLANDER/AMELIE (regulative, scalable *scene* relationships, distributed middleware management)

Conclusion: Organization-Oriented Software Engineering

▷ **Hypotheses**

1. OrgOSE Hypothesis
2. Broadened Perspective Hypothesis
3. ORGAN Hypothesis
4. Nested Middleware Layers Hypothesis
5. Pooling of Competencies Hypothesis

Outlook: What we are working at