A Necessary Paradigm Change to Enable Composable Cloud-based M&S Services

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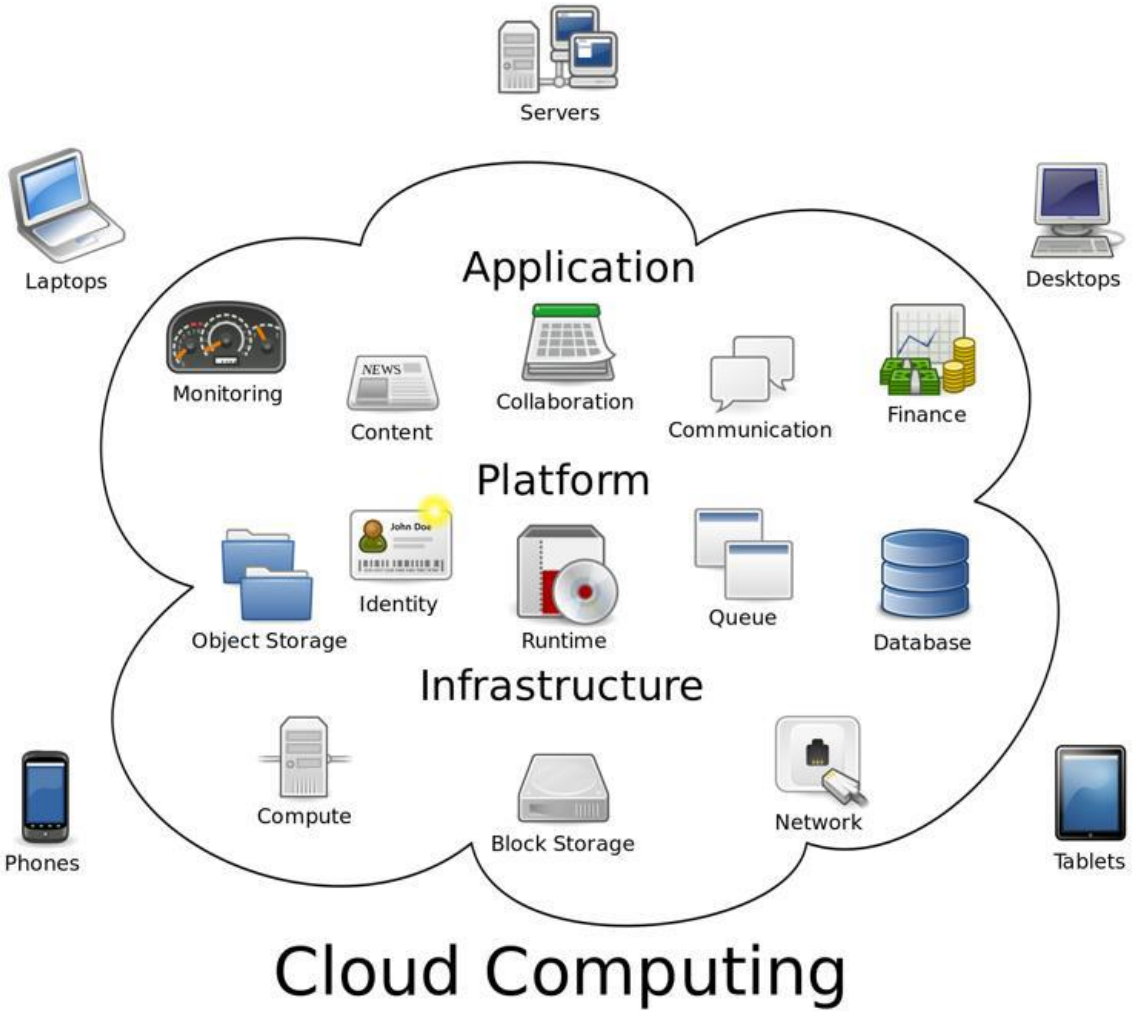
Historical Perspectives

- The Cloud is not a new idea:
  - From the intergalactic computer network of Licklider and the ARPANET (1962) to Amazon's Elastic Compute Cloud (EC2) in 2002
  - Enterprise applications in the Cloud since 2009 becoming the norm
  - Since 2000, M&S Community is focusing on these concepts and working to enable composable M&S Services in the Cloud
- ACM SIGSIM identifies this topic as one of the unfinished tasks for research, in particular at the conceptual level

Cloud-based M&S



Cloud-base Simulation Challenge Perspectives

- Technical perspective
  - How can we do it?
- Governance perspective
  - Who is in charge?
- Security perspective
  - How to make sure that only eligible user have access?
- Business model perspective
  - Who pays for it?
- Conceptual perspective
  - How do we ensure consistency?

Johnson, H. E., and A. Tolk. 2013. "Evaluating the applicability of cloud computing enterprises in support of the next generation of modeling and simulation architectures." *Proceedings of the Military Modeling & Simulation Symposium* (MMS '13)

Interoperability & Composability

- Interoperability
  - The ability to exchange information between systems and the ability to use the information in the receiving system
- Composability
  - The consistent representation of truth in all participating systems

This is already a hard challenge when building federations in the traditional sense. How much harder will this be in the cloud?

The Conceptual Perspective Challenge

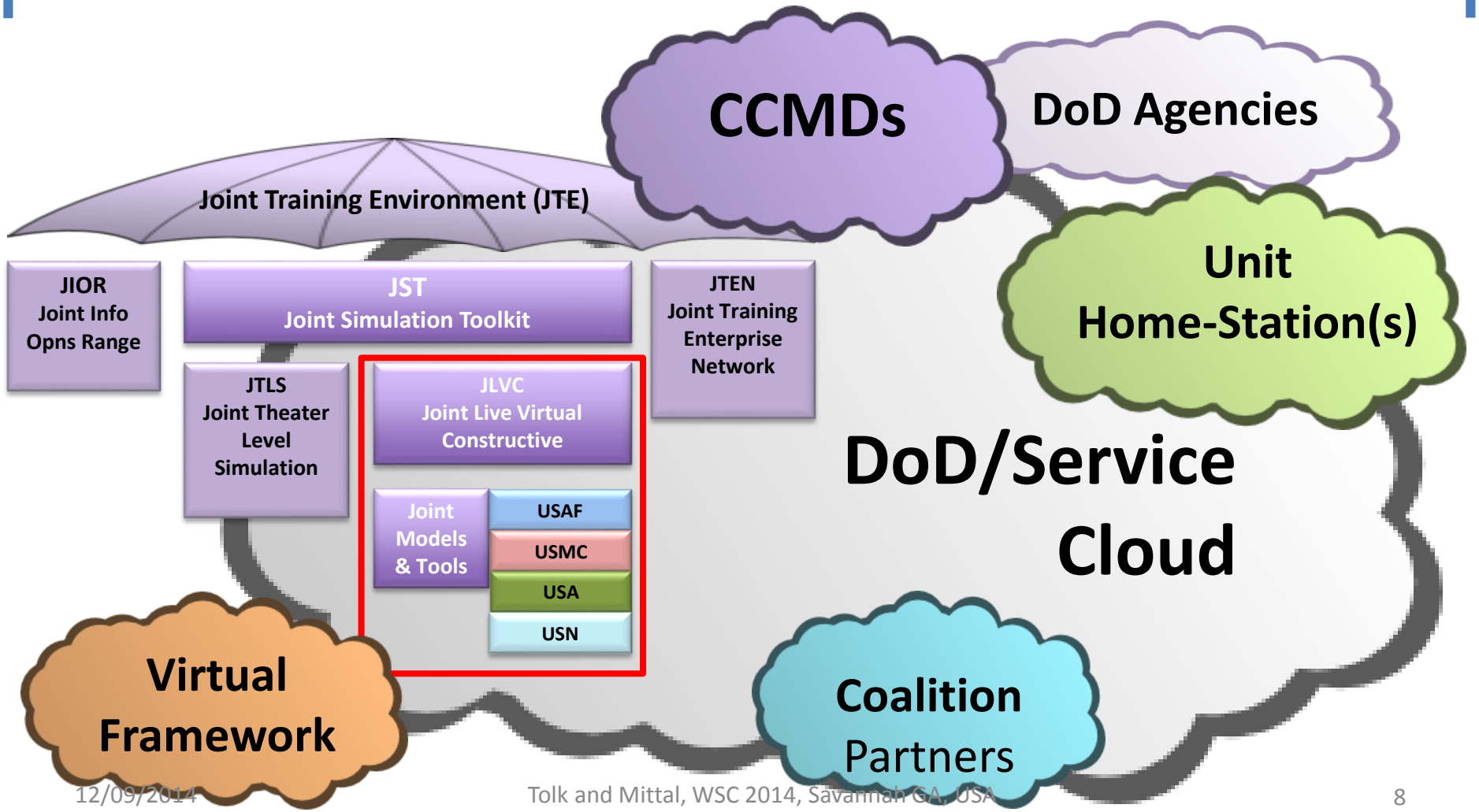
- Insufficiently addressed
- Cannot be completely solved by technology alone
- Model is purposeful abstraction and simplification of a physically and cognitively constrainted perception of reality represented using logic
- Ultimate goal is the consistent representation of truth in all participating systems: a primary requirement and proposed definition for composability

How can the consistent representation of truth in cloud-based environment be ensured?

Composable M&S Services

- Instead of having the collected functionality provided by a complete solution, the user composes his desired functionality ‘on the fly.’
- Tasks and Issues
  - Identification of applicable services
    - Thesauri, semantic mapping issues
  - Selection of best set of solutions/services
    - NP-hard problem
  - Composition of the selected services
    - Data-alignment issue
  - Orchestration of the execution
    - Temporal inconstancies
- Virtualization in Cloud-based M&S does not address these problems sufficiently!

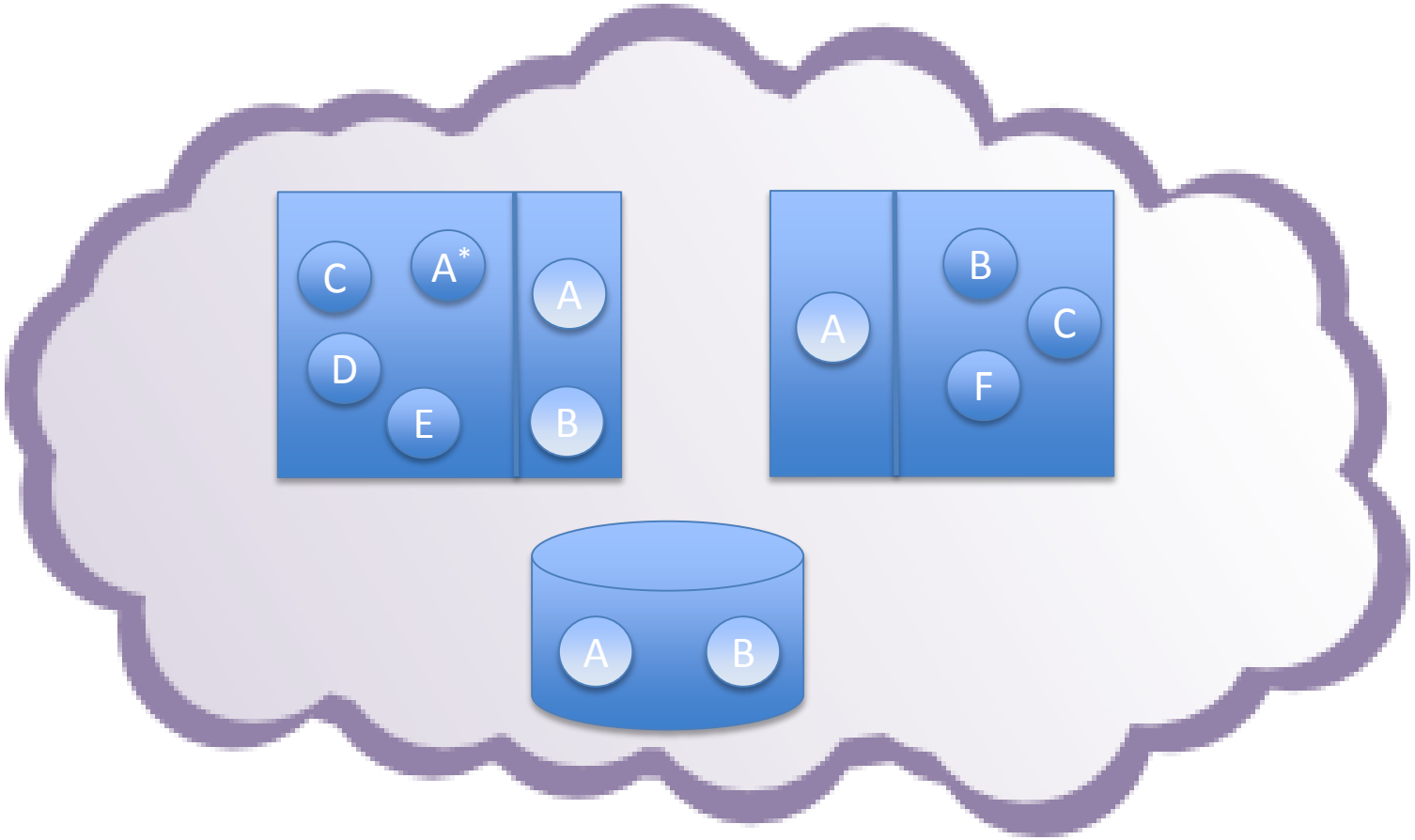
Current View/State of the Art



Problem Definition in the Cloud

- Main challenges are the ***alignment of data*** and the ***orchestration of services***, ensuring the ***consistent representation of truth*** in all services.
- Driving questions:
  - Who owns the simulation?
  - Who owns the state?
  - Who owns the shared situation environment?
  - Who owns the knowledge or the truth?

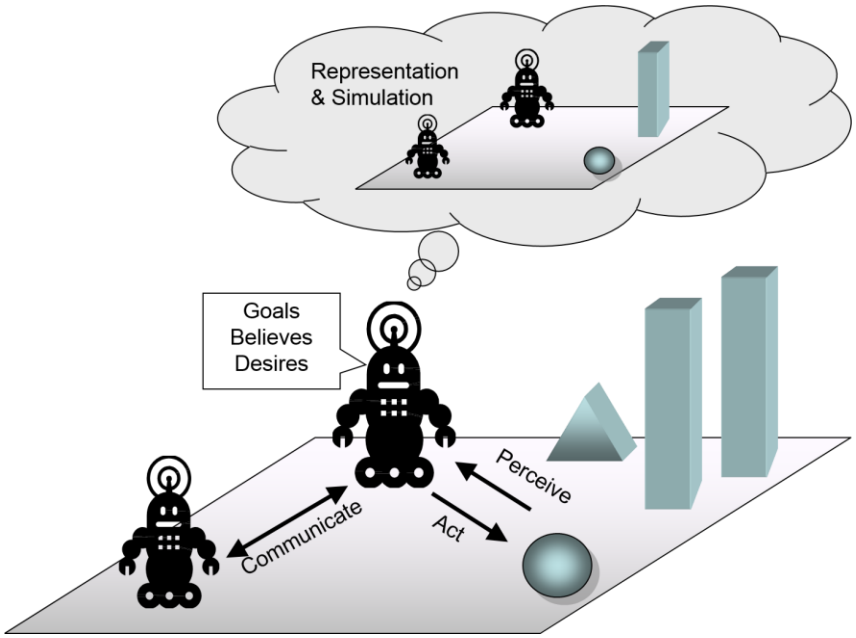
Challenge 1: behind the service curtain



Challenge 2: what's your state?

- Services are invocation based
  - Call a service, and the call is mapped internally
  - No standard event pushed through an RTI, etc.
  - What happens in the service, stays in the service
- Zeigler's Systems Homomorphism
  - Serious of local functions preserving conditions
  - Not supported in the cloud
- State encapsulated in the service cloud
  - Feasibility shown in the SOA-based Event-driven Architecture

Challenge 3: Partial Observability



- Agent observe their environment
  - Based on sensors
  - Partial observations
  - Environment is the same for all agents
- What is the environment in the cloud?
  - Independent environments presented by each service
  - No shared environment

More challenges

- Knowledge distribution
  - Ontologies of services are not aligned
  - SMEs and knowledge engineers of services are not well connected
- What time is it
  - There is no common RTI
  - Do we provide a central time service?
  - Do we provide relative time?

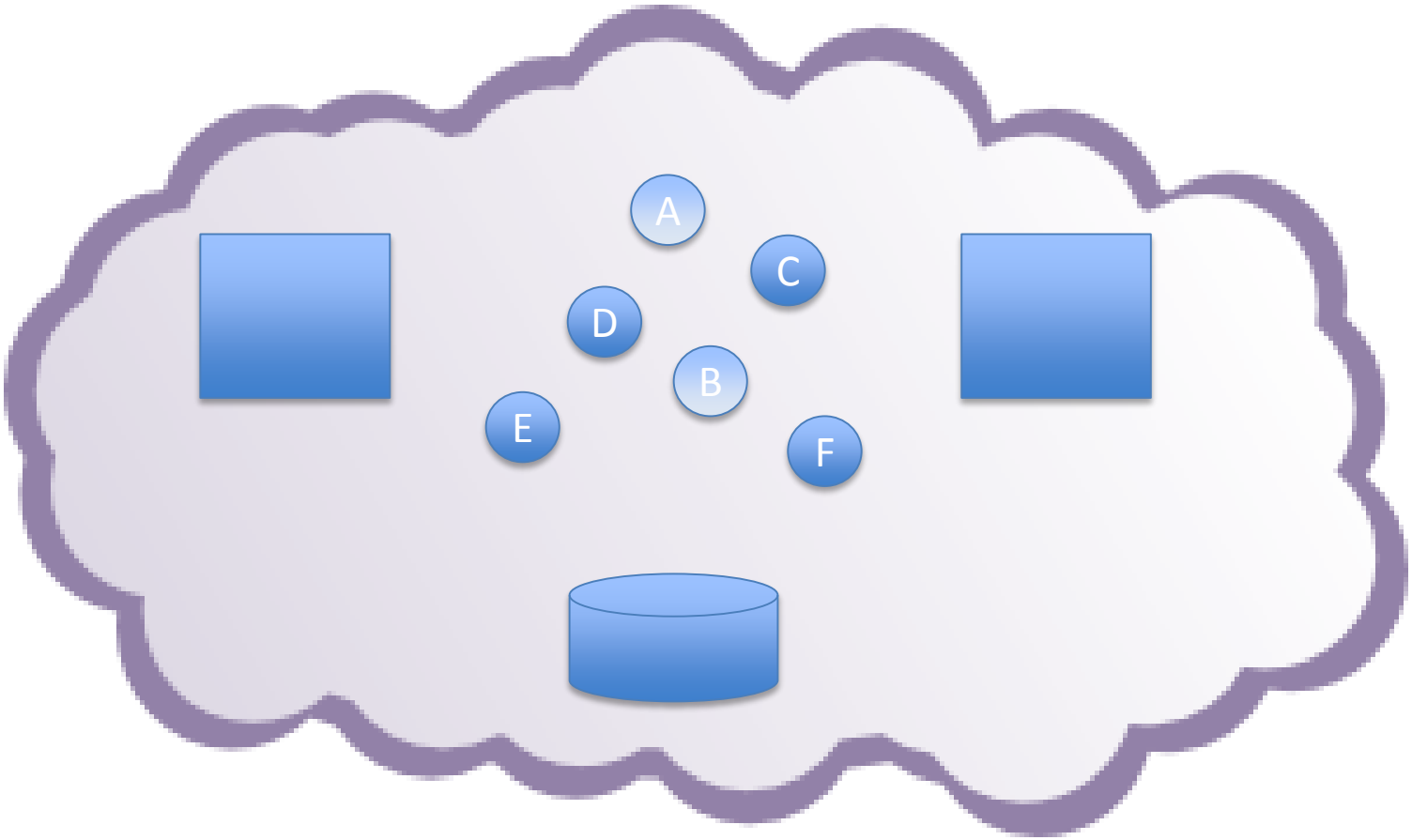
Proposed Solution

- A paradigm shift:
  - Truth to be maintained at run-time
  - Run-time infrastructure to be the strengthened for interoperability
- Mobile Propertied Agents to align truth and data
- Floating middleware to implement an event-service bus (ESB) for orchestration of events

Mobile Propertied Agents

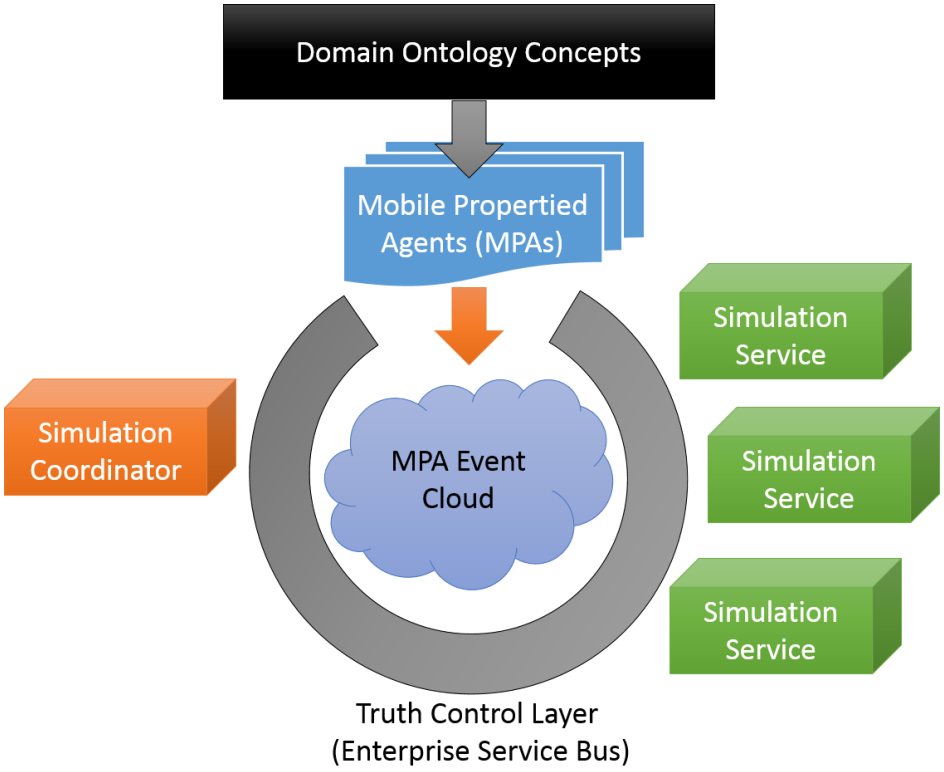
- An MPA is an agent that
  - encapsulates a semantic concept,
  - its associated properties by way of syntactic data elements and
  - provides interfaces to manipulate the properties by external services.
- An MPA contains
  - a state-machine to record the current state of the encapsulated properties as it gets dynamically invoked by the external federates who want to use the particular semantic concept.

MPAs in the Cloud



Concept-driven Service Architecture

- Event Cloud
  - MPA (entities)
  - Event-query language
- Simulation Services
  - Provide the simulation functionality
- Simulation Coordinator
  - Implements the overall protocol
  - Selects the services
- Truth Control Layer
  - Consistent invocation
- Enterprise Service Bus
  - Coordinates TCL and services



Discussion

- Separation of entities (concepts) and their states from services results in consistency within the cloud, but
  - Services need to be conceptualization-agnostic
  - Model-based solutions (services with states) require more work/alignment, as they still follow the 'old' paradigm
  - Direct Manipulation of agent properties that are all public may create discussion in the ABM community
- This solution is in its infancy, but
  - Addresses conceptual challenges
  - has been proven to be feasible

Questions

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