Critical Systems Evolve
because they are embedded in
Socio-Technical Ecosystems

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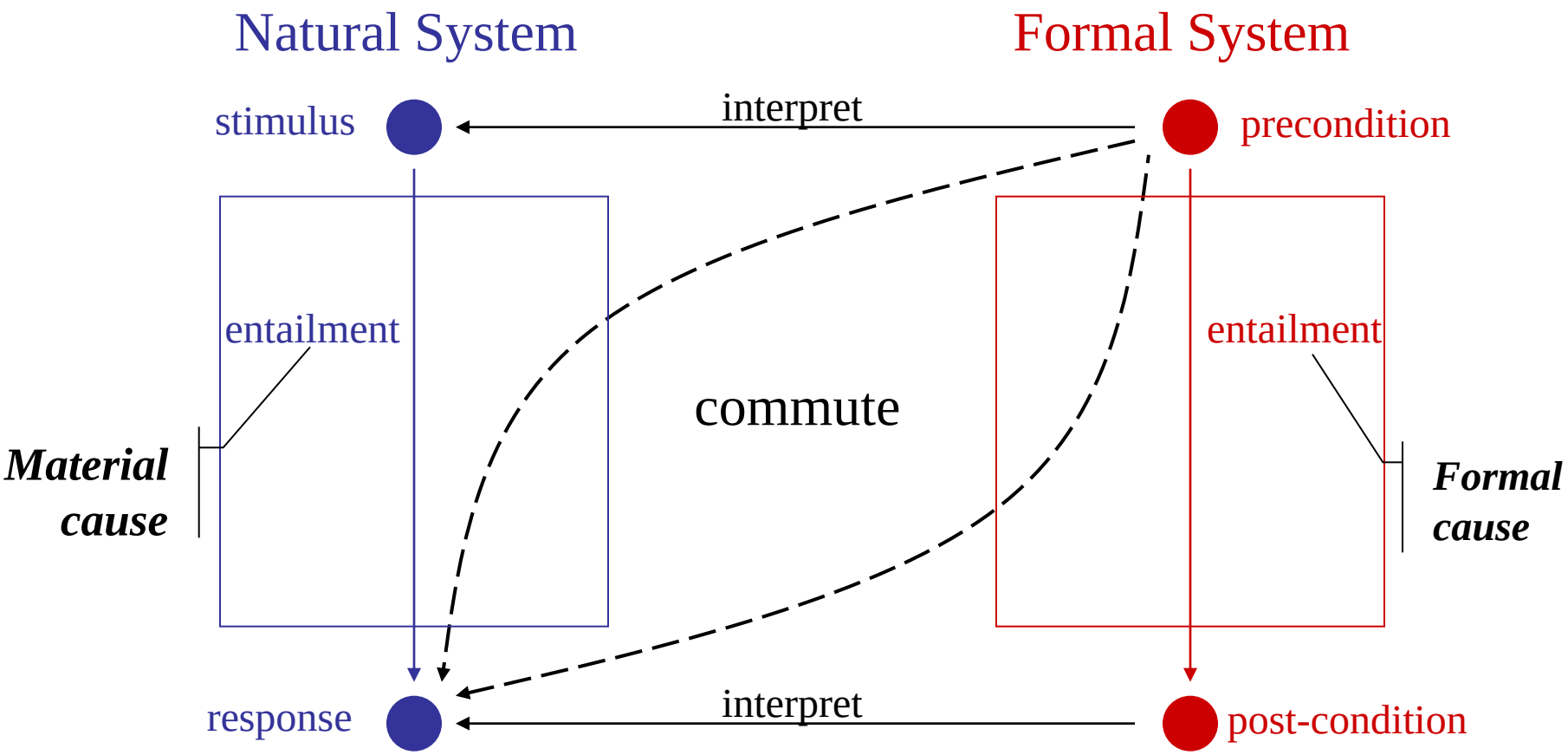
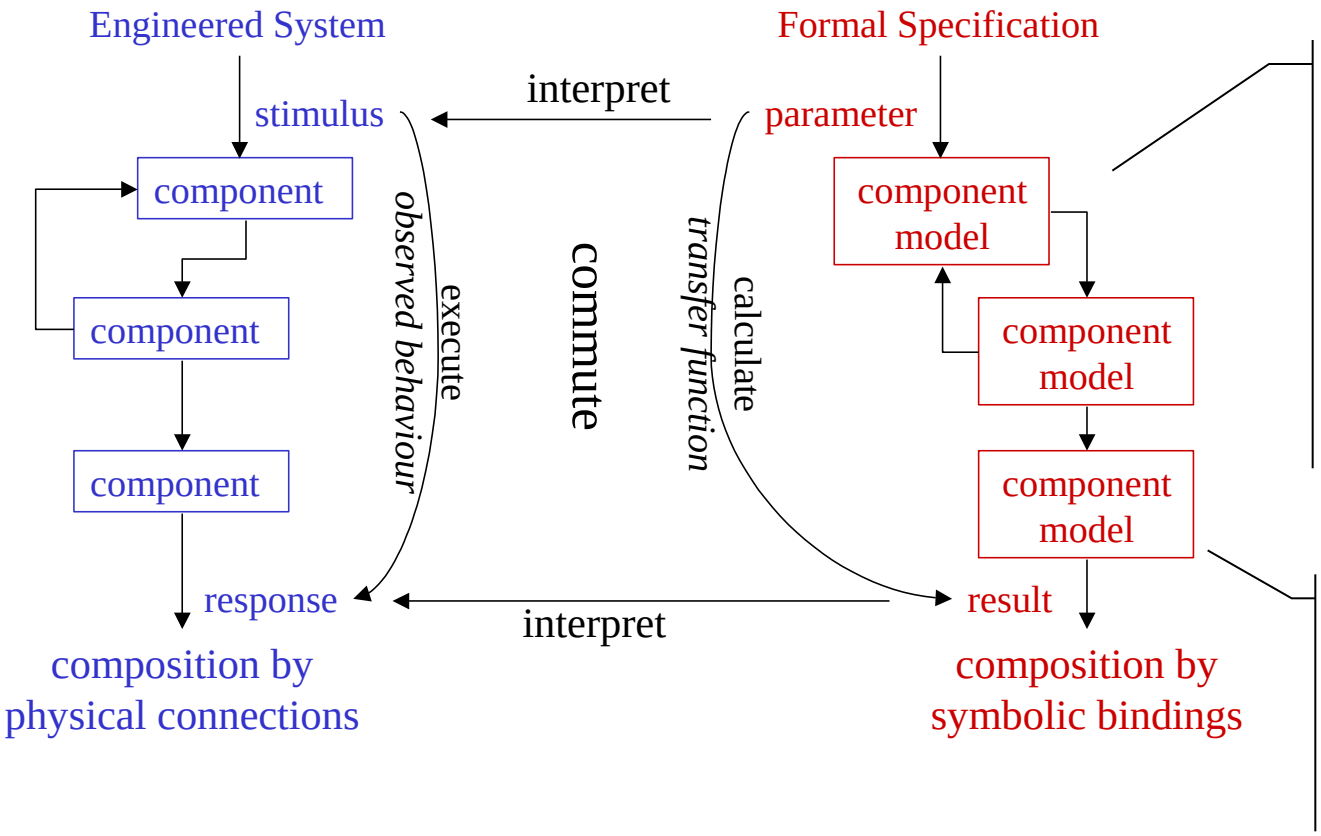
The Modelling Relation: Scientific Knowledge



Ontological Commitment:

To be is to be the value of a variable [W. V. O. Quine]

The Modelling Relation: Engineering



Design engineers identify as components just those closed systems whose models provide computationally effective composition calculi.

Engineering disciplines are characterised both by their component models and by their collections of compositional operators.

Closed Systems and the Frame Problem

- ***The Frame Problem***: *in an **open system**, one cannot identify the set of all state components that are **not** altered by the occurrence of an event.*

  first identified in *Some Philosophical Problems from the Standpoint of Artificial Intelligence*, McCarthy and Hayes, 1969
- Science and engineering make the simplifying assumption that the natural systems they observe are **closed**, that is, immune to disturbance from all stimuli that the operative model does **not** account for.
- This distinction between what is and what is not accounted for by the observer's knowledge is the observer's **Cartesian cut**:
- *What you see is not what you get*

Forms of Governance

Systems of Systems [SoS] can be distinguished by the nature of the managerial control exerted over how their component systems work together

- **Directed** SoS – treating the SoS as a single system where the uses of the SoS are pre-determined by a central authority
  - e.g. air defence system
- **Collaboratively Directed** SoS – where the uses of the SoS require collaboration among the constituent elements for the SoS to fulfil an agreed upon central purpose
  - e.g. the physical internet
- **Distributed Collaboration (Virtual)** SoS – where there is no centrally agreed upon purpose for the SoS, so that the SoS must rely upon relatively invisible mechanisms ('rules') to maintain it
  - e.g. the World Wide Web of content across the internet

* from "Architecting Principles for Systems of Systems", by Mark W. Maier, University of Alabama. http://www.infoed.com/open/papers/systems.htm

Ontological Commitment

- In the case of directed or collaboratively directed composition, there is ultimately a centrally determined ontological commitment (i.e. to what the system will be) over-determining the uses of the SoS:
  - the integrated system-of-systems is built and managed to fulfil specific purposes. (e.g. integrated air defence network); and
  - the component systems maintain an ability to operate independently, but their normal operational mode is subordinated to the central managed purpose.
- But in the case of distributed collaboration, some ontological commitment is deferred to the time of use. This means that any centrally determined ontological commitment has to be under-determining of the uses of the SoS
  - central management organisation does not have coercive power to run the system (e.g. internet, which started out as a directed SoS); and
  - the component systems are autonomous to the extent that they voluntarily collaborate to fulfil agreed upon purposes.

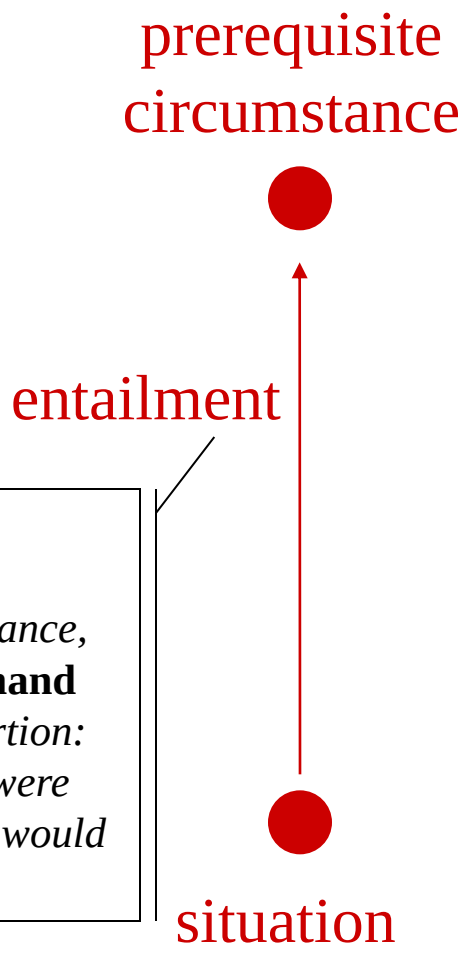
The Orchestrating User

- All the relevant compositional approaches can be known in a closed SoS.
  - But without knowledge of a closed SoS's domain of behaviour, it would be experienced as open, because its composition is under-determined by its design.
  - Hence, "emergent behaviour": the actual composite behaviour of the SoS differs from the observer's composition of its parts because its composition is not fully understood,
    - so that the SoS is, in effect, engaging in autonomous composition which is affected by its interactions with the user (e.g. feature interaction in telecoms etc.)
- This difference between systems whose behaviour can be predicted by the user independent of their use of it, versus those that cannot, is the user's

- ***Heisenberg cut***:
- *What you get depends on how you use it*

Anticipatory System

The clients for
composed services
(the composite functionality
delivered by an SoS)
are **actors**.

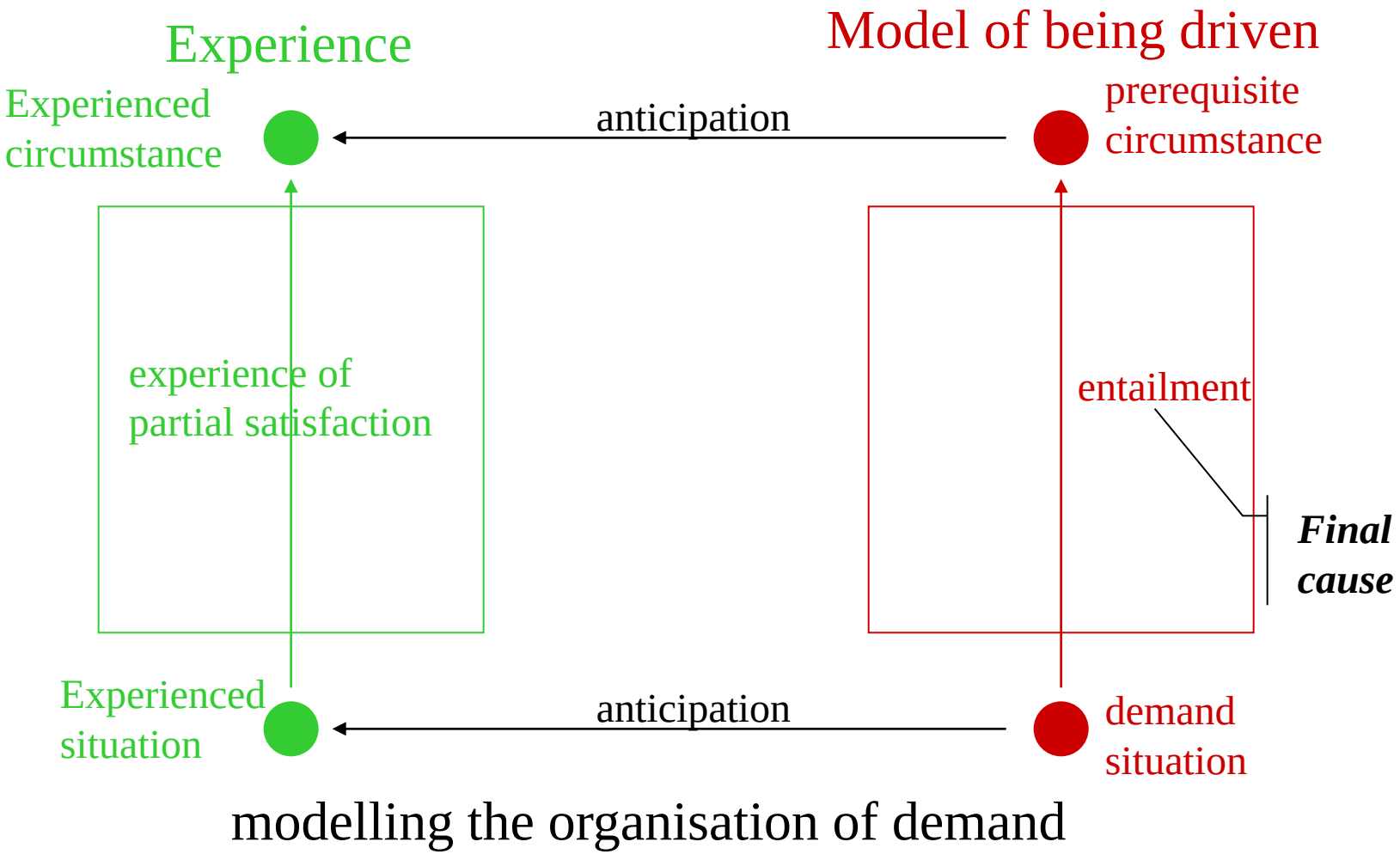


Final cause:
in the system's **context-of-use**,
the situation entails the circumstance,
because the user's **model of demand**
contains the *counterfactual assertion:*
if the prerequisite circumstance were
not to pertain, then the situation would
not occur.

Actors are **anticipatory systems**
(as defined by Robert Rosen)
who derive their
demands for services
from their formulation of
themselves as context-of-use
(e.g. as an enterprise)
for those services.

Anticipative systems are complex
adaptive systems

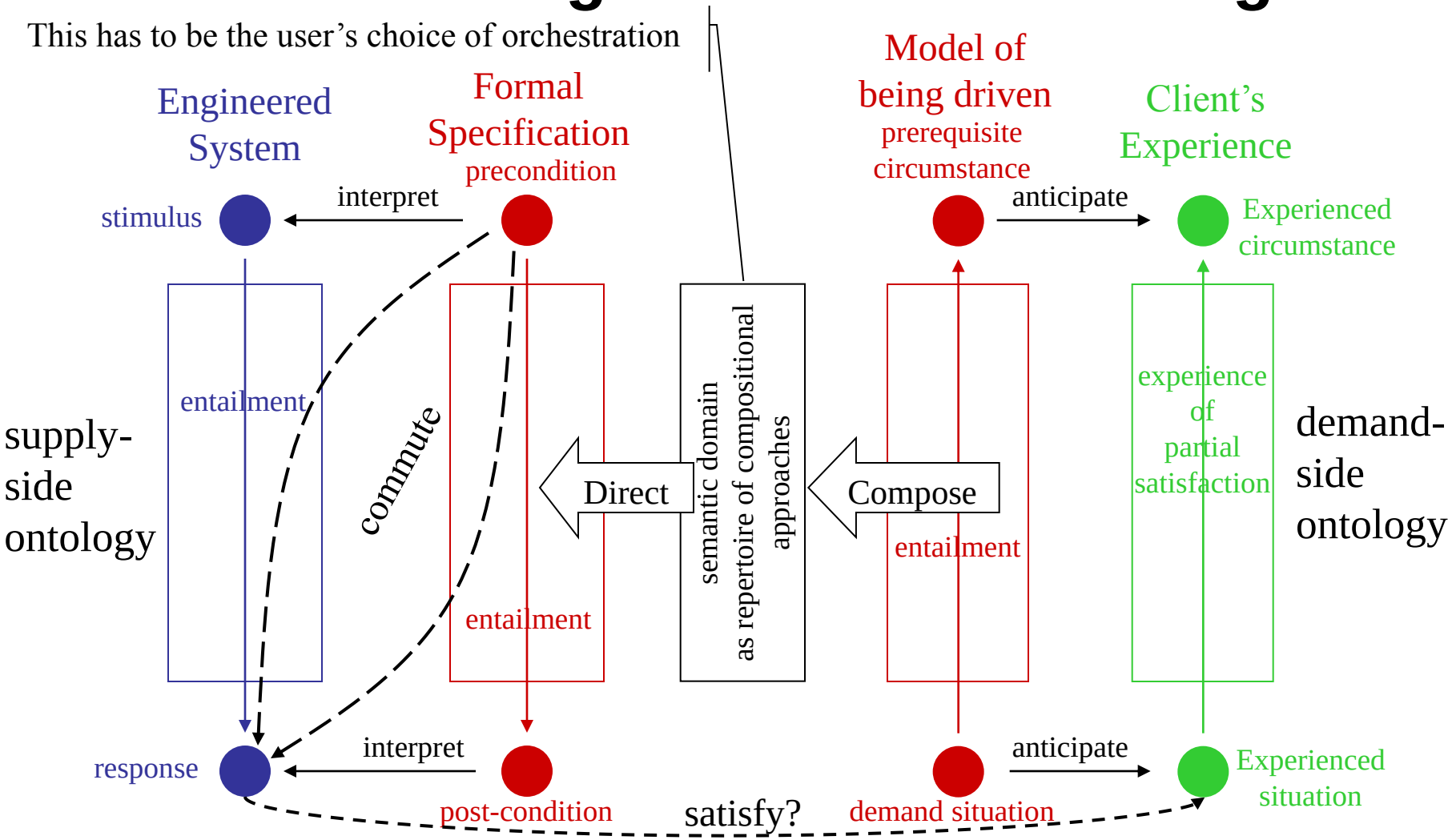
The Modelling Relation: Pragmatics



The Frame Problem Revisited

- Understanding the client to be an anticipatory system, and given that anticipatory systems are open systems, then the modelling of the needs of the client suffers too from the Frame Problem.
- But the client's **modelling** of his/her need in the form of an **organisation of demand** constitutes a **pragmatics of use,** which can be modelled. i.e. the client cannot know his or her needs directly, but rather can know them indirectly through his or her experience of their effects.
- This difference between what can and cannot be known directly by the client about his/her needs is the client's **'endo-exo' cut**
- *What I want is never exactly what I ask for.*

The Modelling Relation: SoS Design

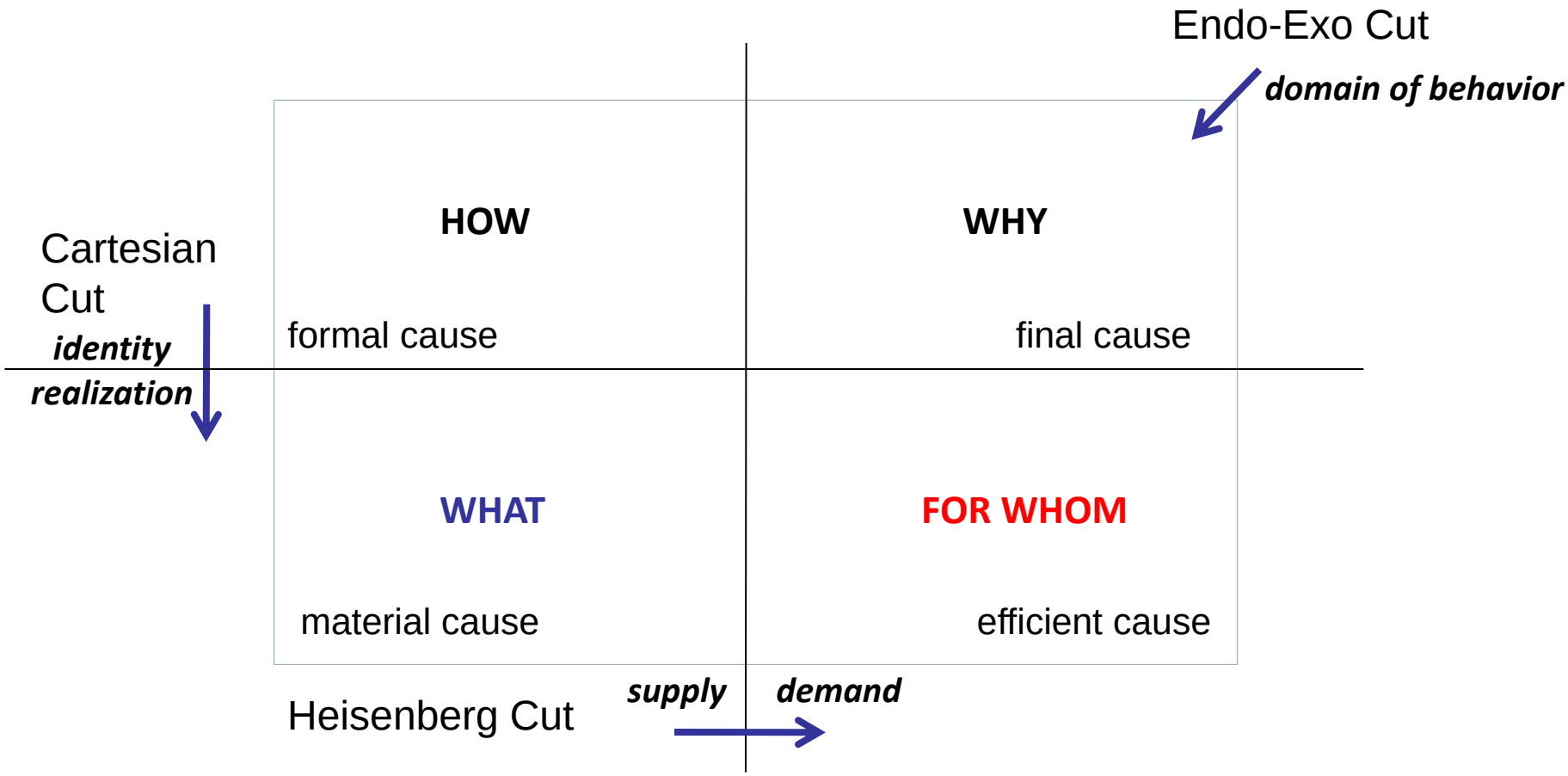


Modeling socio-technical systems

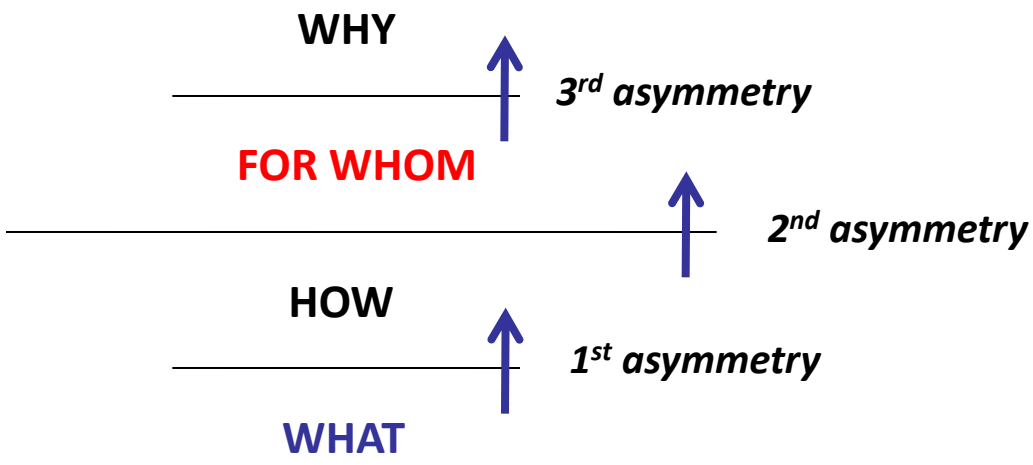
In order to model a client enterprise as a socio-technical system, it is necessary to situate the observer's perspective:

1. The Domain of behavior: Who is your client?
   - i.e. in terms of what kinds of behavior is it defined?
2. The What: What does your client do?
   - i.e. what is the material nature of the work they do?
3. The Who for Whom: Who are their customers?
   - i.e. who is your client serving (and what are the economics of this)
4. The How: What are the critical identity-defining characteristics of your client that makes them who they are?
   - i.e. what are those aspects of how they are organized that are identity defining?
5. The Why: what makes those identity-defining characteristics of the client of value within the larger ecosystem of which they are part, particularly in relation to their customers?
   - i.e. what are the drivers in the larger eco-system that makes what your client does of value

Defining how the client stratifies their relationship to demand



Stratification



The Asymmetries and Stratification

Economies of Scale

1st asymmetry
the technology does not define the product

Economies of Scope

2nd asymmetry
the business model does not define the customer's solution

Economies of Alignment

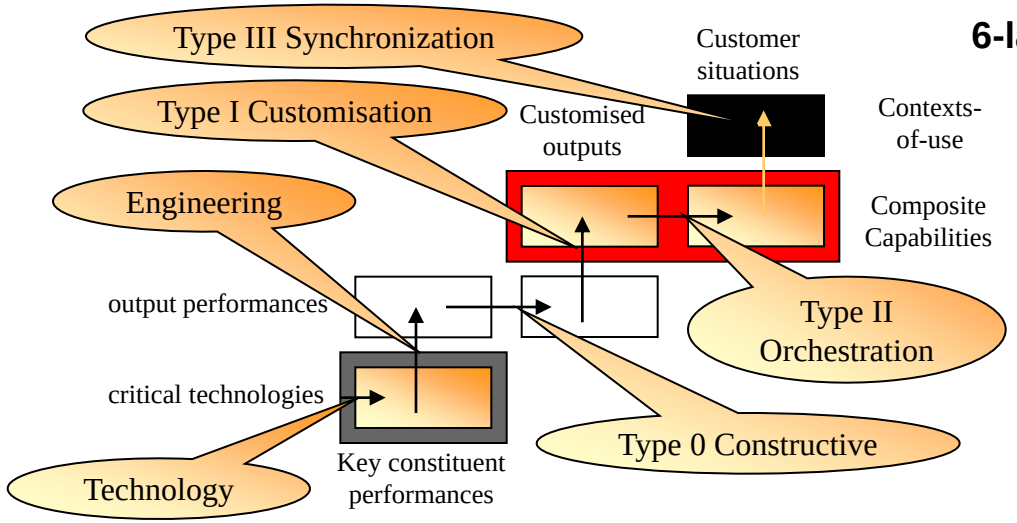
3rd asymmetry
the customer's demand does not define the experience that the customer wants

Blue Team:
What are the *critical technologies* that you have to be able to master and/or source in creating your products (*constituent performances*)?

White Team:
What are the *key constituent performances* that you need in order to construct the *output performances* that go into your market channels?

Red Team:
How are you going to have to *customise* and *orchestrate outputs* to generate the *composite capabilities* you need to synchronize with the customer situations you are targeting?

Black Team:
What are the *contexts-of-use* and *customer situations* that are generating the demands that you are targeting, and how will you *synchronize* the composite capabilities needed to satisfy them?



PAN (Projective ANalysis)
Tools for Socio-Technical Systems Engineering

Visual PAN elicit graphical, relational representation of client's enterprise model.

Stratifier transform into stratified Boolean matrix

Analyser compute projections of stratified matrix

Cohesion trace paths through stratifed matrix

Landscape generate 3D histograms of Boolean matrices considered as simplicial complexes

Feed results back to client:

- classification, location and magnitude of risks
- quantifying value and competitive advantage of flexibility,agility, etc.