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Towards Purpose to Function Transition, a systematic approach

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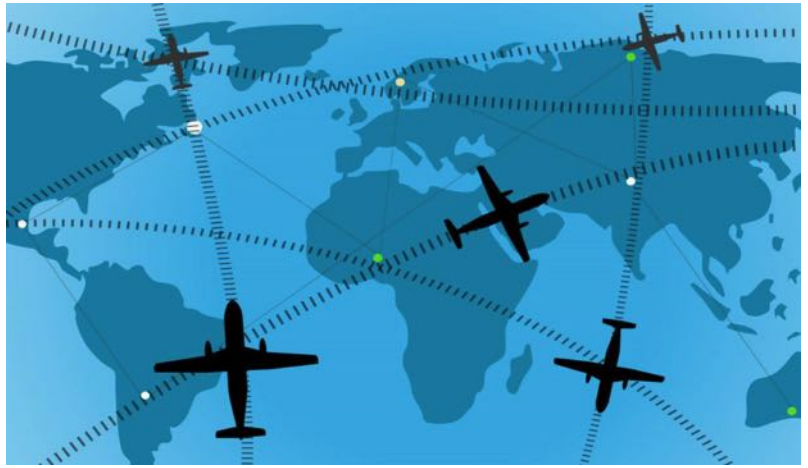
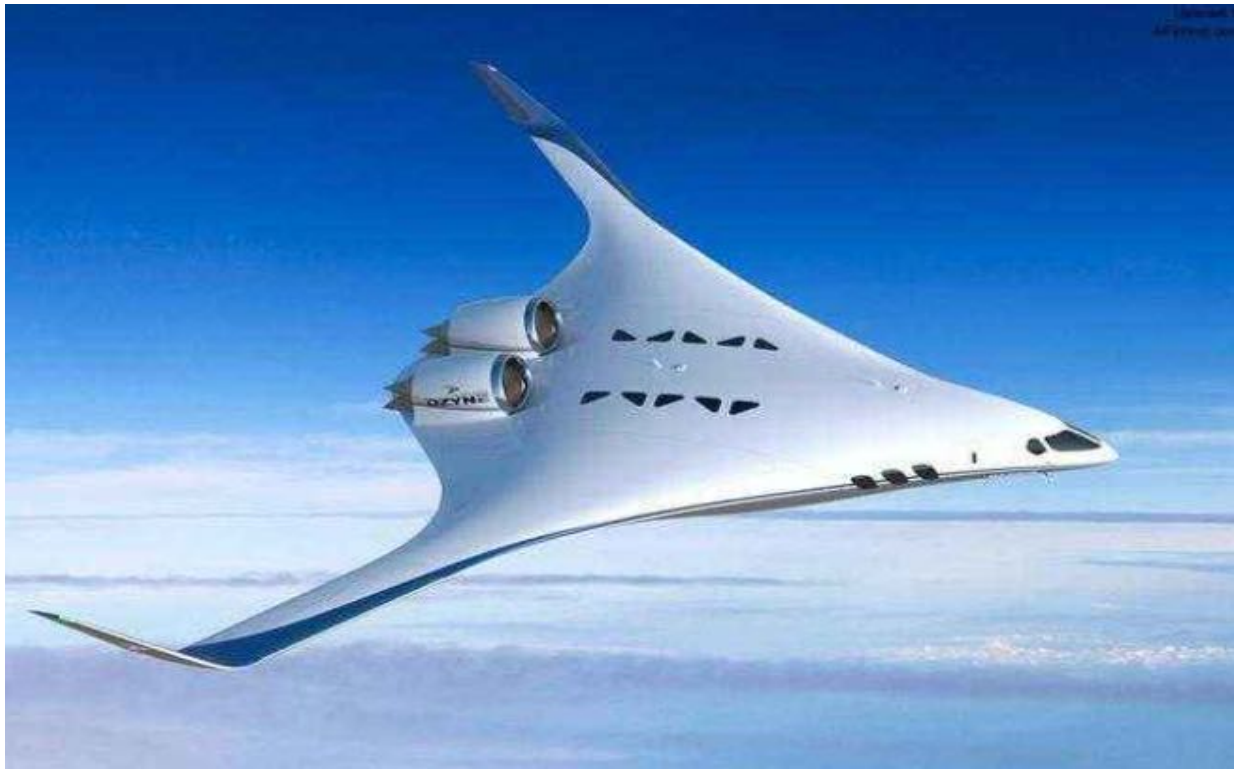
1. Background
2. Scenario-based approach
   a. Scenario identification
   b. Scenario creation
   c. Scenario representation
3. A illustrative case
4. Discussion & Conclusion

Agenda

1. Background





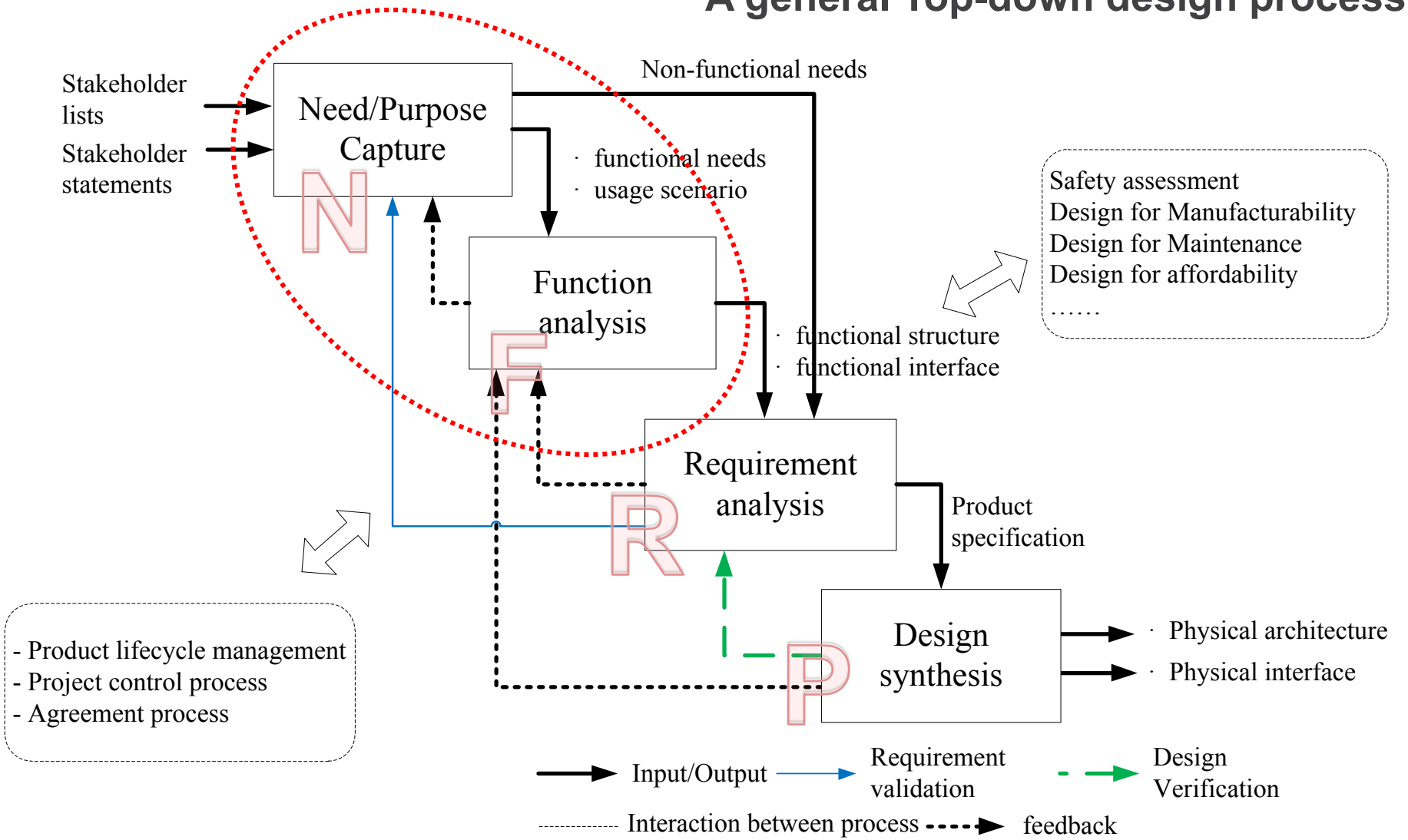
Blended Wing Body

1. Background

Metro Bus

1. Background

A general Top-down design process model



COMAC systems engineering handbook, 2017

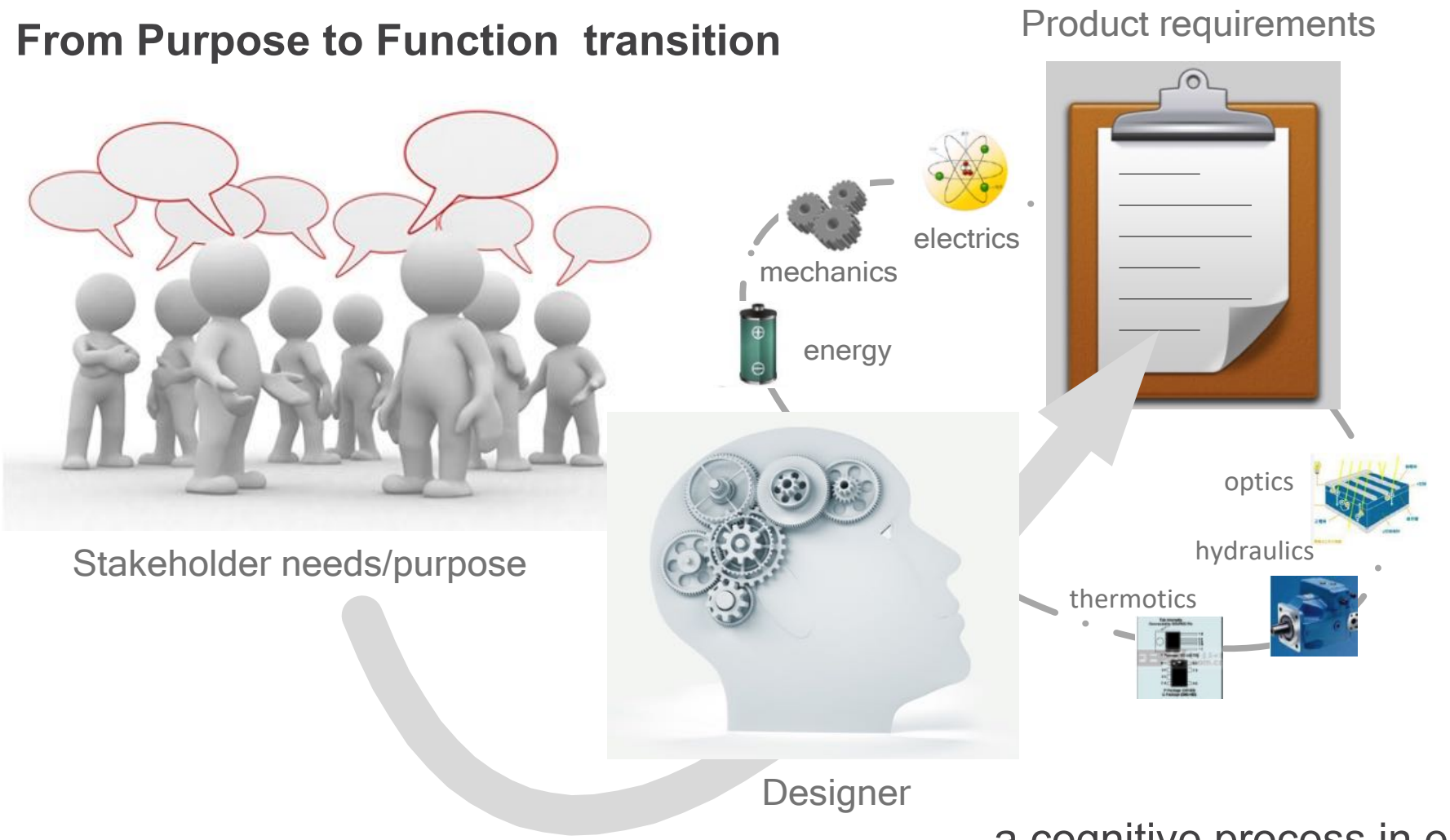
1. Background

Difference between '*Purpose*' and '*Function*'

Purpose/Need	Function
Background in a social-cultural environment	Background in a techno-physical environment
Described concretely in a context	Described in a high level abstraction
Usually represented in a informal manner, natural language	Usually represented in a formal manner, verb-noun pair or input-output flow, syntactic language
Customer-oriented, stems from the statements of customer needs	Designer-oriented, depends on designer's perception of the needs

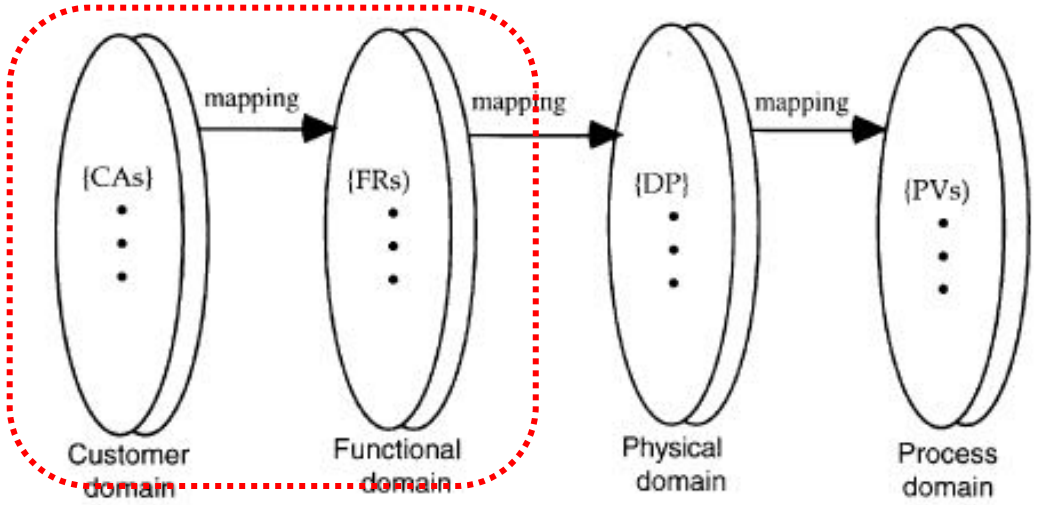
1. Background

From Purpose to Function transition

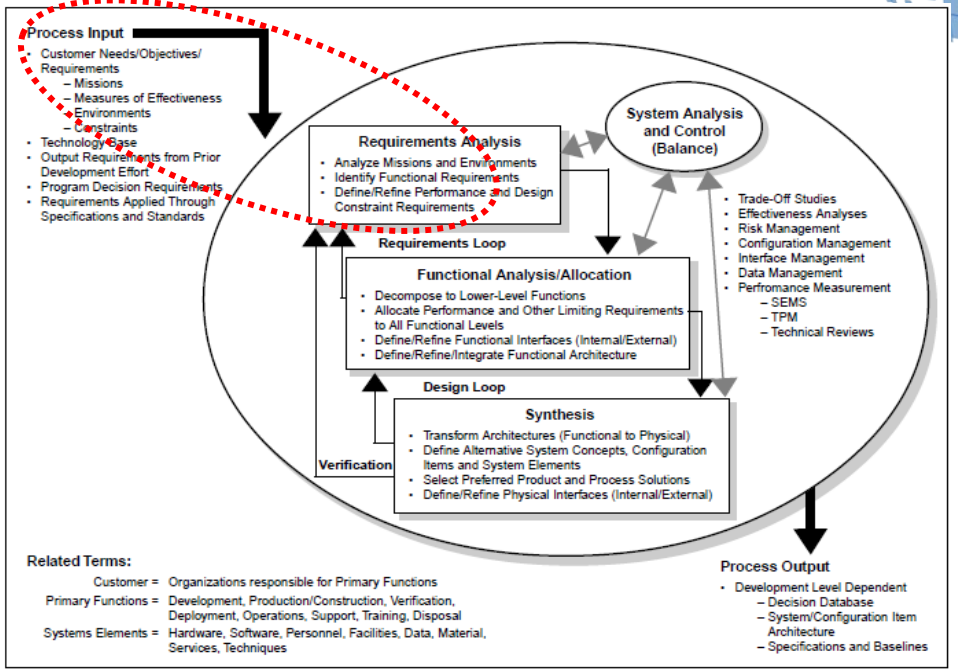


a cognitive process in early design

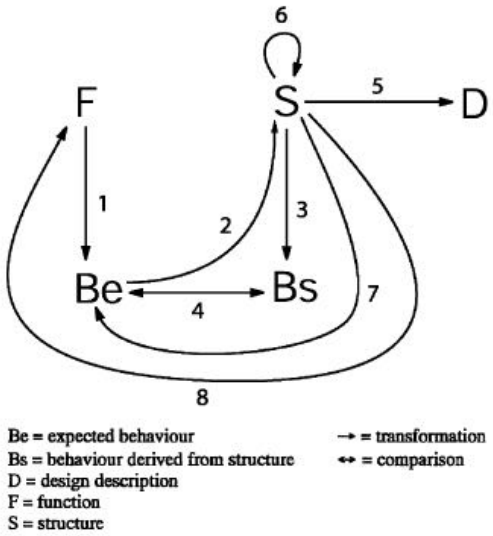
1. Background

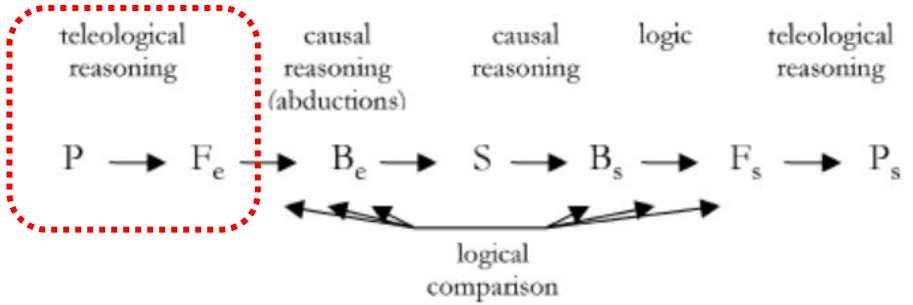


Axiomatic Design, Nam. Suh, 1998



NASA systems engineering handbook



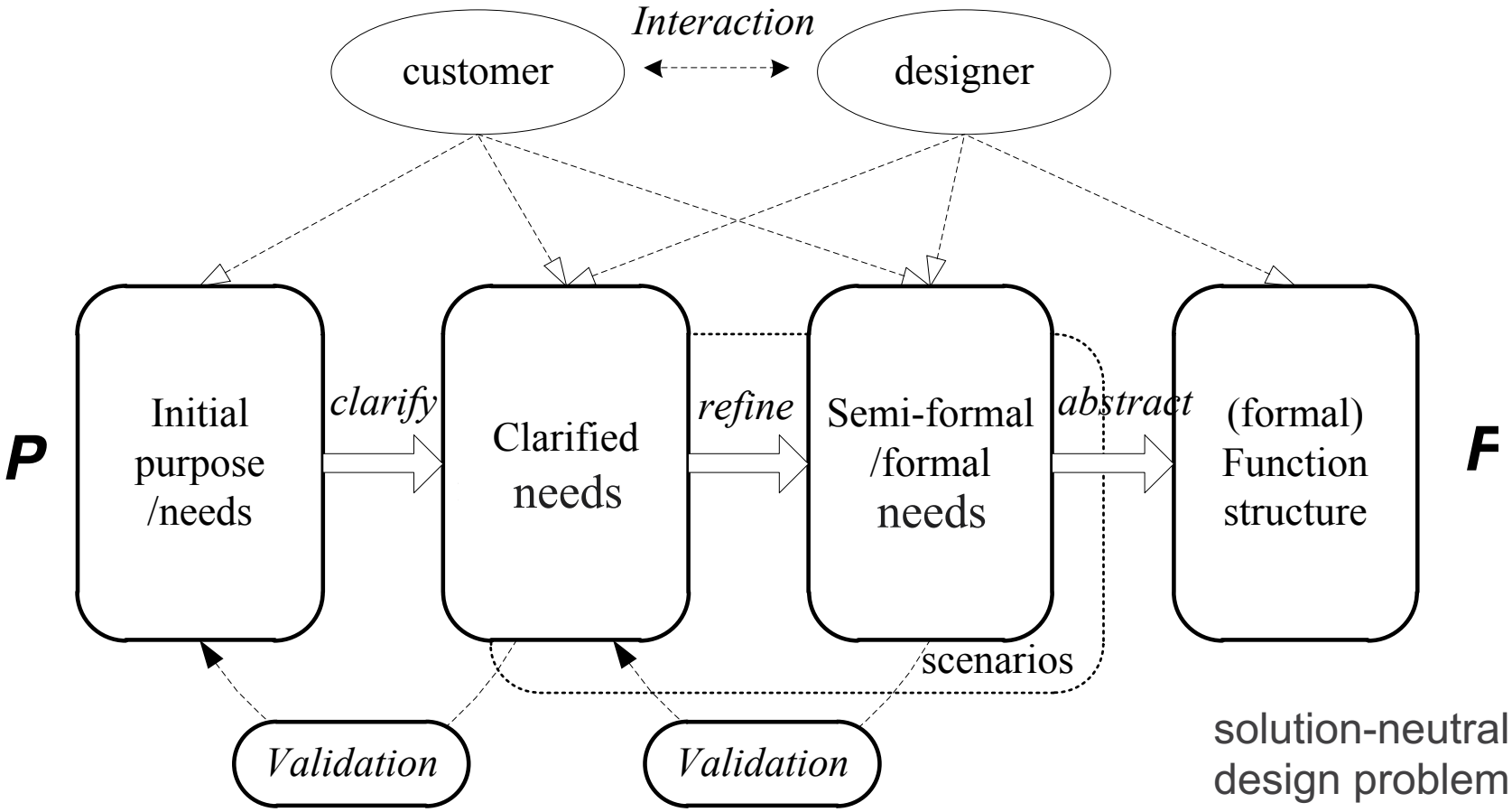


Adaptive F-B-S model, Gero J, 2002

Scenario-based purpose to function transition

2. Scenario-based approach

P → F transition process model



solution-neutrally representing a design problem

2. Scenario-based approach

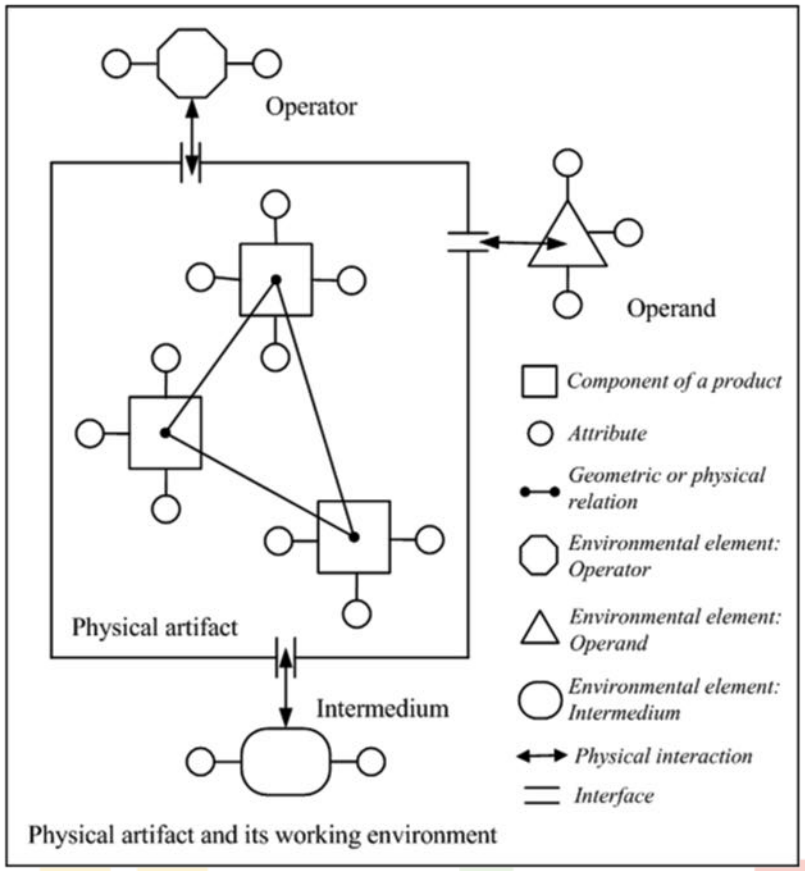
What is an artifact scenario?

Concept:

Scenarios are narrative descriptions of activities of an artifact. It can be used to model the interactions between an artifact and its working environment.

Contents (characteristic elements):

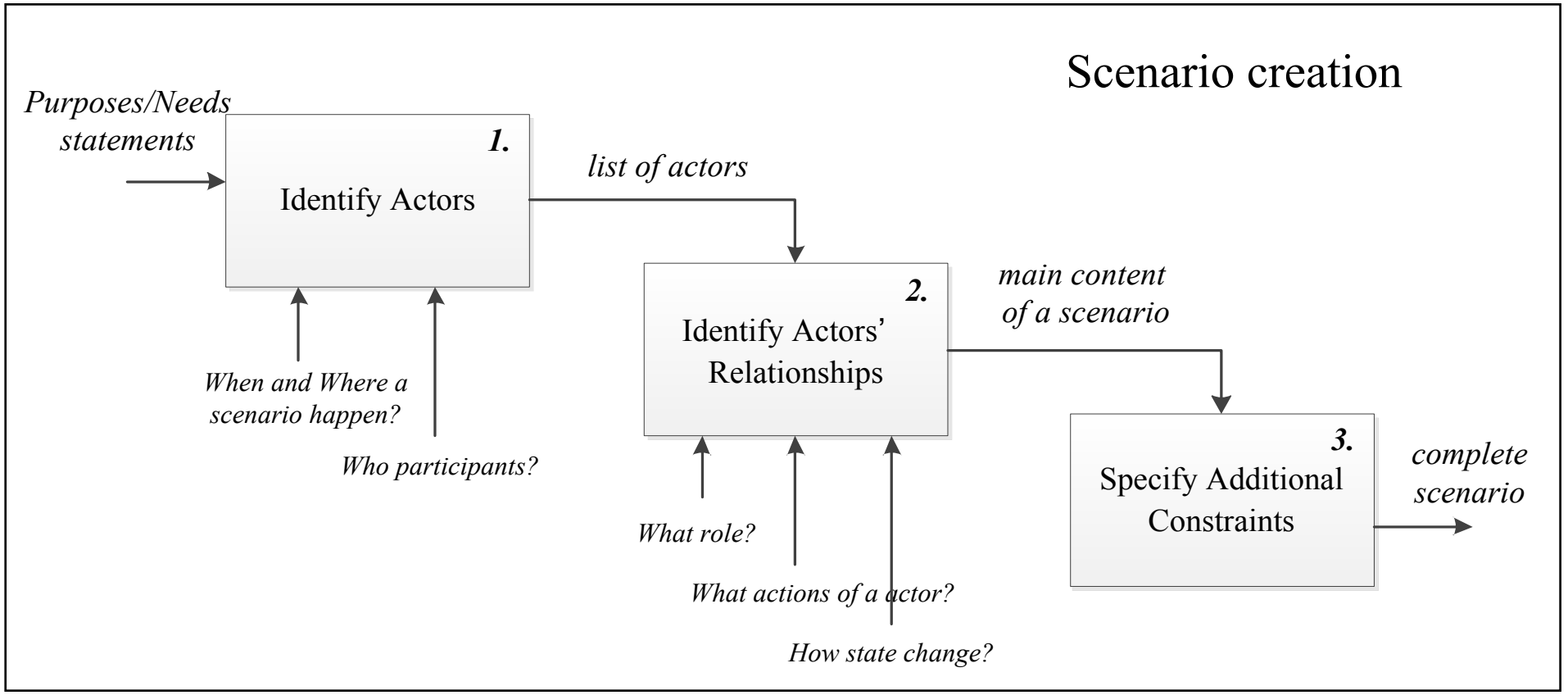
- - Actor/agent
- - Action/event
- - Situation



The interactions between artifact and environment (modified from Deng, 2000])

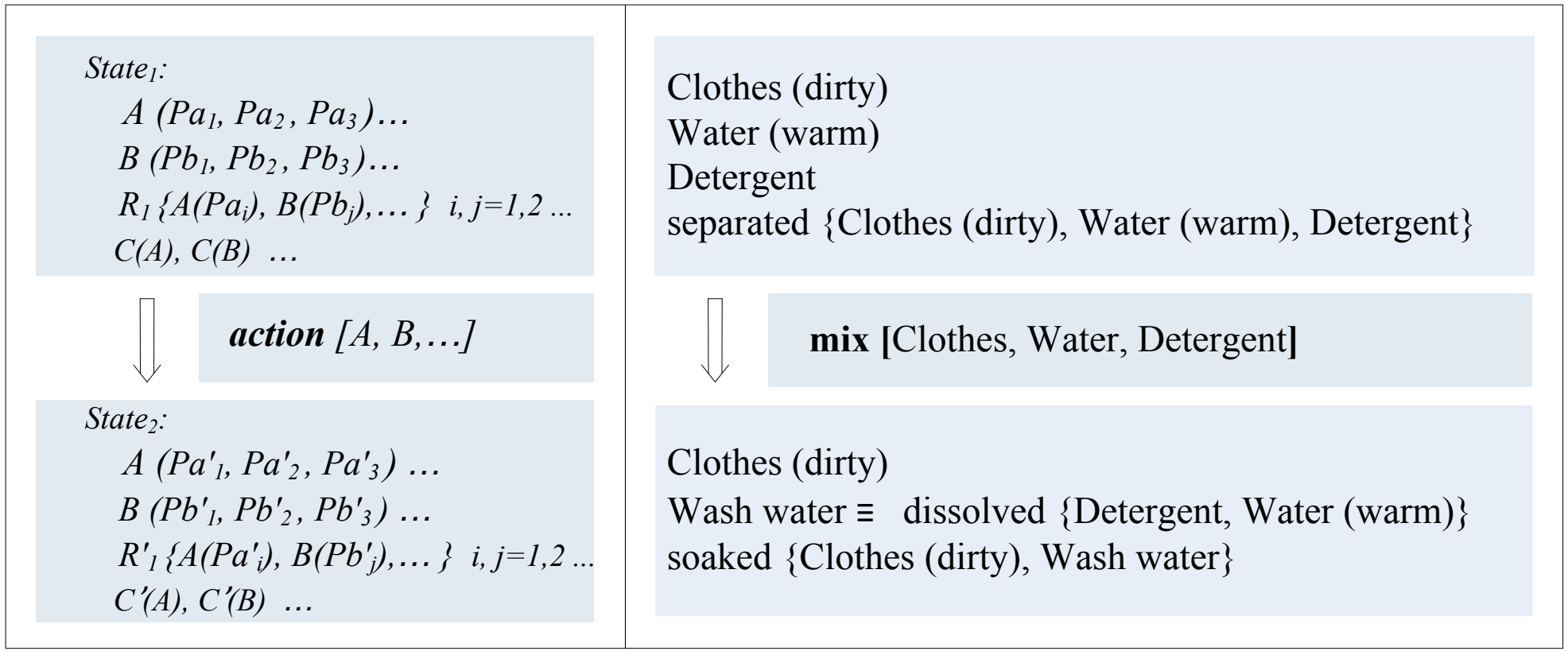
2. Scenario-based approach

The process to create an artifact scenario:



2. Scenario-based approach

Formal representation of an artifact scenario:



An illustrative case

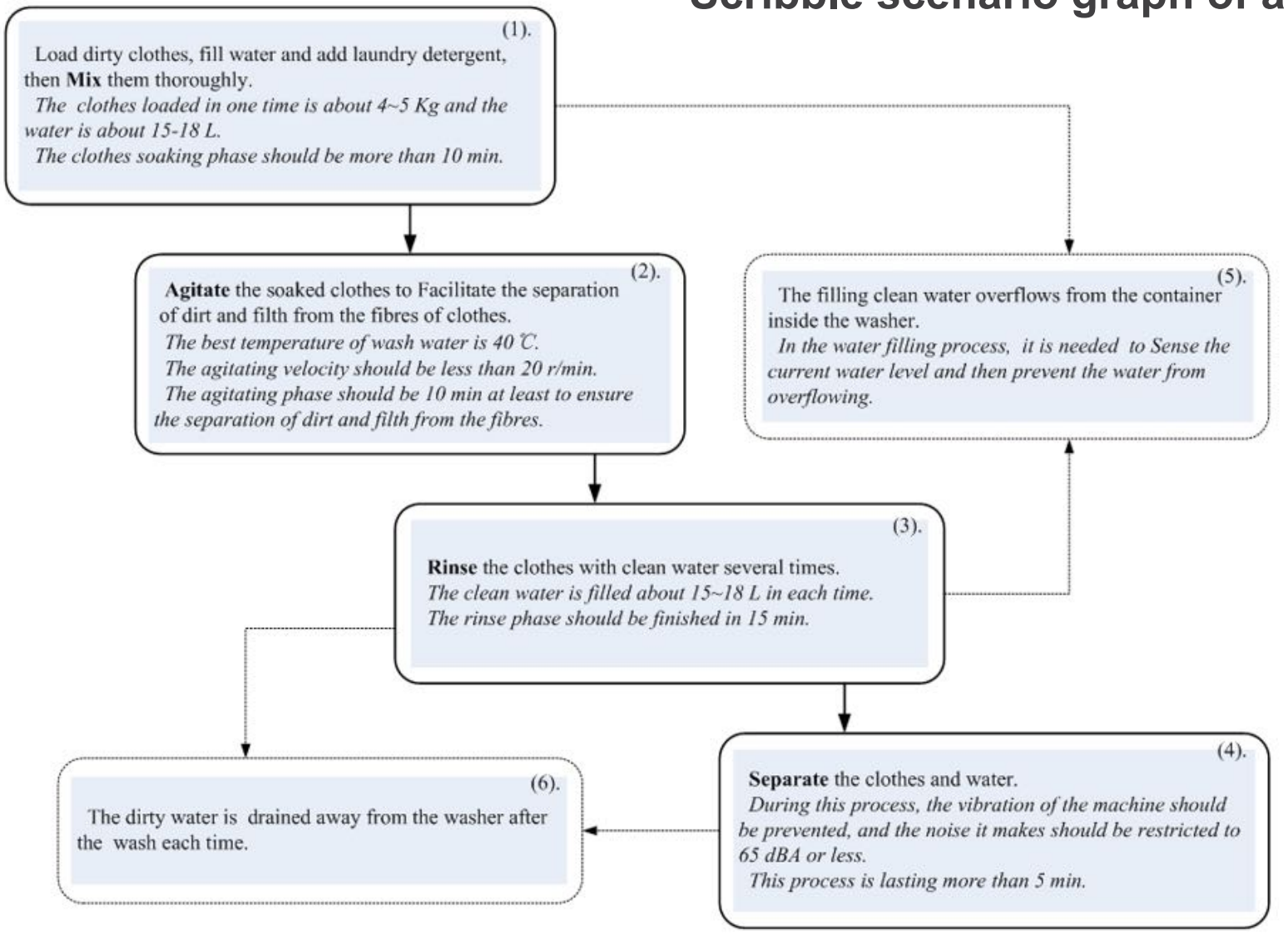
3. An illustrative case

Washing machine (Washer)

Laundering by hand involves beating and scrubbing dirty cloth, which is hard work even with manufactured aids like washboards and detergent to help. Thus, customers require an appliance to wash family members' clothes with little labor. Automatic cloth washing would be fine and the washing process should be finished within 50~60 min. Because this machine is designed for use in house, the installation and transportation of such machine by customers should also be taken into account. Moreover, the price should be affordable to a common family.

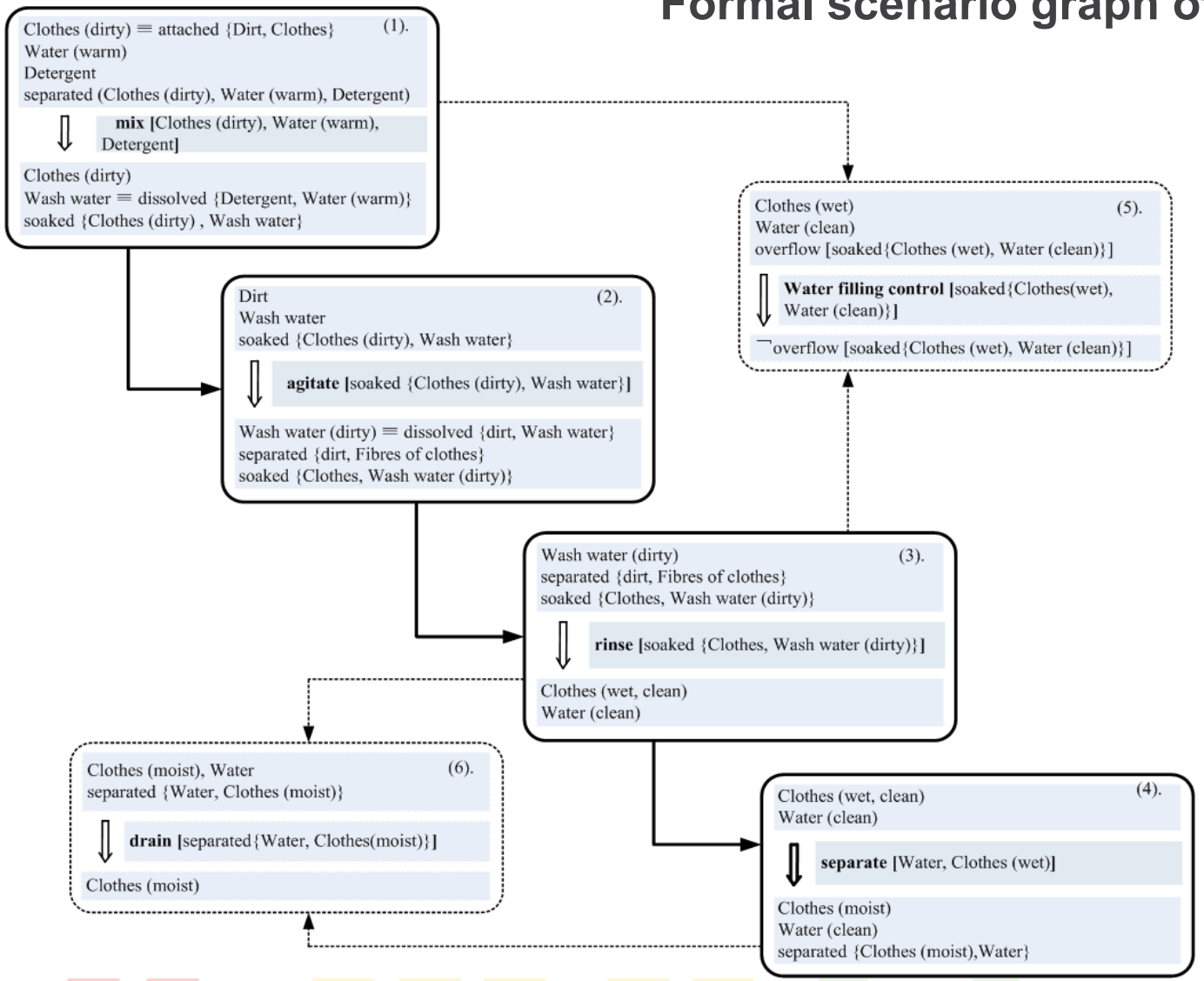
3. An illustrative case

Scribble scenario graph of a washing machine



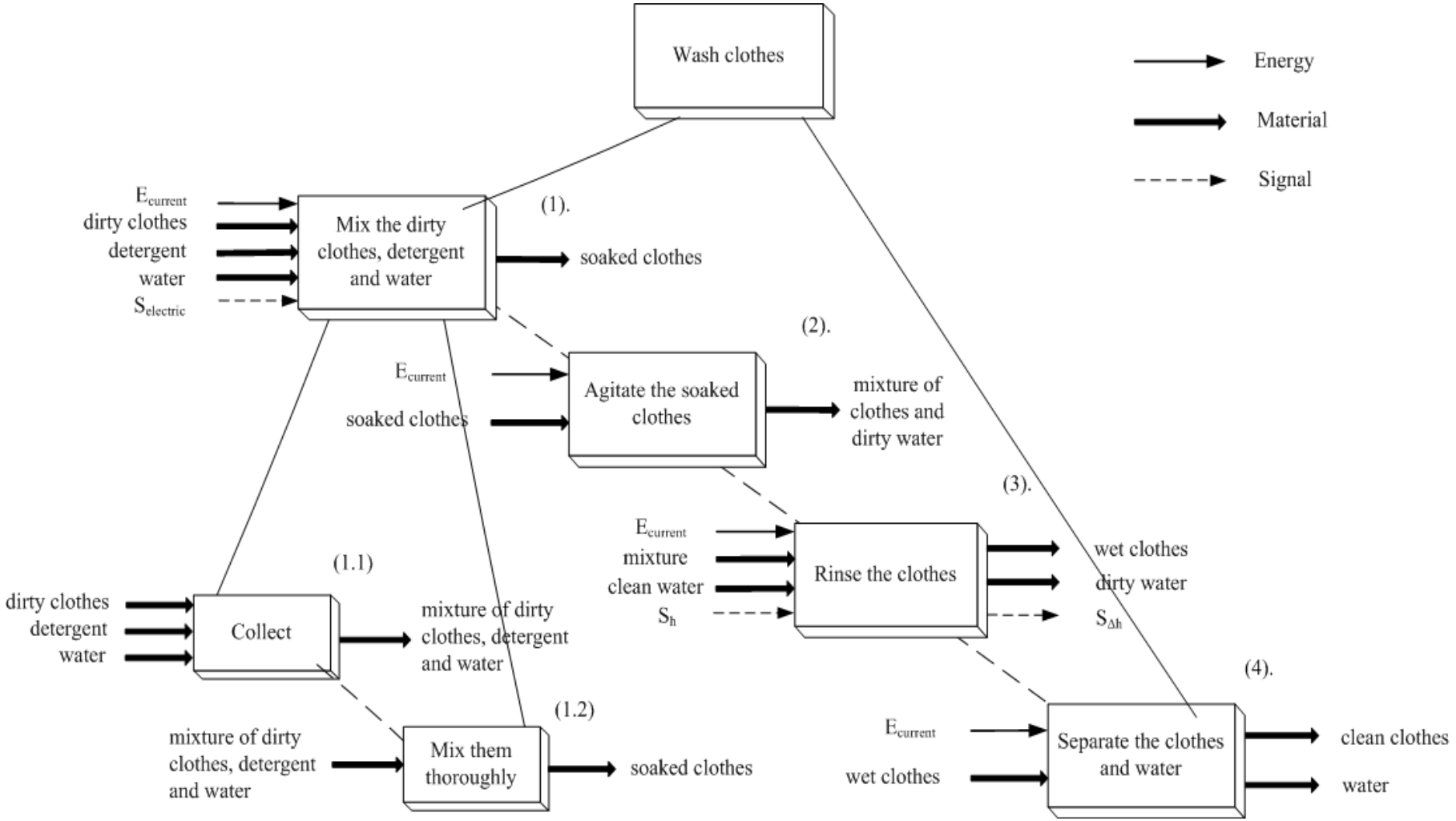
3. An illustrative case

Formal scenario graph of a washing machine



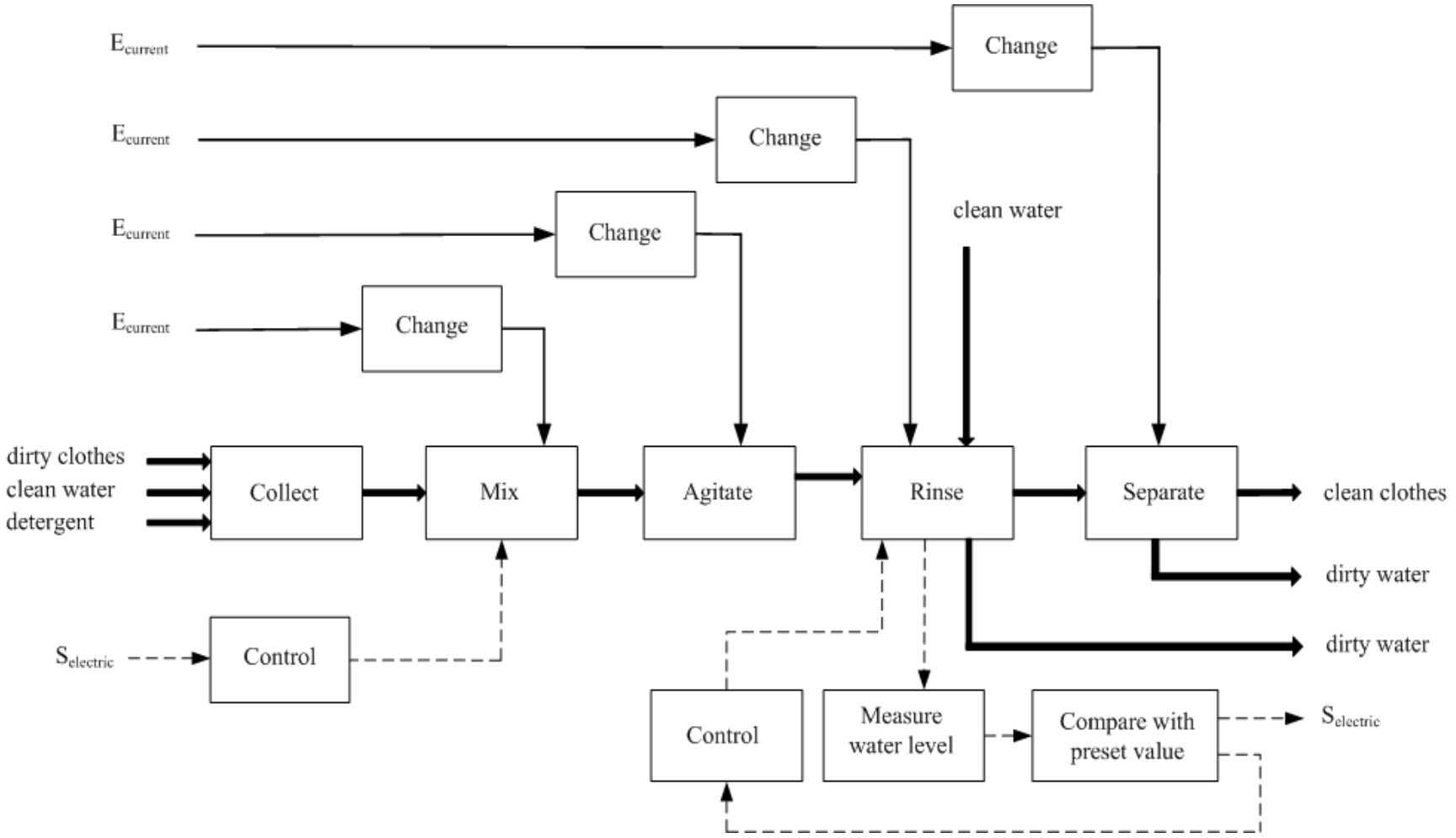
3. An illustrative case

Preliminary function abstraction



3. An illustrative case

Function structure of the washing machine



Discussion & Conclusion

4. Discussion

Informal scenario

(1).
Load dirty clothes, fill water and add laundry detergent, then **Mix** them thoroughly.
The clothes loaded in one time is about 4~5 Kg and the water is about 15-18 L.
The clothes soaking phase should be more than 10 min.

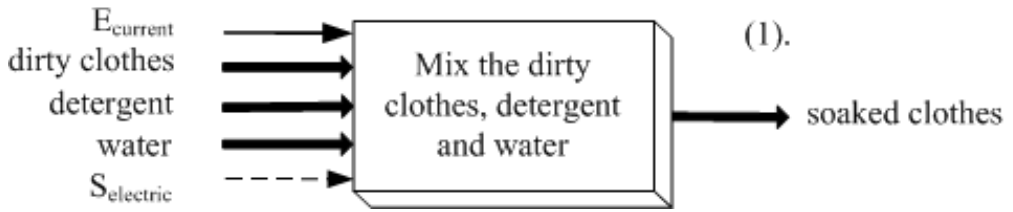
Formal scenario

Clothes (dirty) ≡ attached {Dirt, Clothes} (1)
Water (warm) *one time(amount(Clothes))=4~5 (Kg)*
Detergent *one time(amount(Water))=15~18 (L)*
separated (Clothes (dirty), Water (warm), Detergent)

⇩ **mix** [Clothes (dirty), Water (warm), Detergent]

Clothes (dirty) *waterproof (material(Container))*
Wash water ≡ dissolved {Detergent, Water (warm)}
soaked {Clothes (dirty) , Wash water}
*time span(**mix**[Clothes(dirty),Water(warm),Detergent)]≥ 10 min*

Function abstraction



4. Conclusion

- Facilitate the communication as information carrier *;*
- Pre-decomposes the initial needs/purpose in a certain level before the function abstraction;
- From the creation of informal scenario hierarchy to the formal scenario hierarchy, and then to the function structure is a stepwise process, and the latter is built on the basis of its former, then the traceability of requirements are established as well.

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Thank you!

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