PANEL on ICN/ICONS

The Fourteenth International Conference on Networks ICN 2015

The Tenth International Conference on Systems ICONS 2015

Topic: New Directions on Networks and Systems

NexComm Conference, April 19-24, Barcelona

PANEL on ICN/ICONS

Moderator

Eugen Borcoci, University "Politehnica“ of Bucharest (UPB), Romania

Panelists

- **Jacques Verriet**, TNO-ESI, the Netherlands
- **Mark Austin,** University of Maryland, USA
- **Tomasz Hyla**, West Pomeranian University of Technology, Szczecin, Poland
- **Roberto Sebastian Legaspi,** The Institute of Statistical Mathematics, Japan
- **Eugen Borcoci,** University "Politehnica"of Bucharest (UPB), Romania

Panel ICN/ICONS

- **Panel Topics**

- **Jacques Verriet**
  - **……**

- **Mark Austin:**
  - **Opportunities for model-based design of networked systems using ontologies, rules and message passing mechanisms**

- **Tomasz Hyla:**
  - **How security shapes systems design?**
    - **about the human factor and social engineering techniques used to gain access to IT systems**
    - **an approach to system design in mobile banking**

Panel ICN/ICONS

- **Panel Topics**

- **Roberto Sebastian Legaspi**
  - Embedding some requisite laws in the network-centric modeling of systems resilience
  - proposal of a a framework that would integrate and realize the laws of requisite complexity, diversity, and knowledge to achieve this end

- **Eugen Borcoci**
  - Software Defined Networking technology - Use cases and challenges

- **Thanks!**

- **Floor to the panelists..**
- **Comments, Q/As…**

ICN/SOFTNETORKING 2015

Software Defined Networking Technology – Perspectives and Challenges

(focus on Standardization Aspects)

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NexComm 2015, April 19-24, Barcelona

SDN - standardization aspects

- **Topic:**
  - **Software Defined Networking (SDN) technology - standardization aspects**
  - **Motivation of this talk**
    - SDN – emergent, promising technology for clouds, WANs, SP networks, etc.
    - Standards bodies, Industry associations, Research, etc., work on SDN
    - This shows a real interest and promising perspectives
    - However, some overlapping and even (partially) not- compatible approaches happen
    - **Additional effort is needed, to:**
      - **produce complementary consistent work**
      - **avoid duplicate work and incompatible standards**
  - **Acknowledgement:**
    - **This presentation has been compiled by using several sources- see Reference list**
    - Good reference on the subject: [1] J.M. Halpern, "Standards Collision around SDN", IEEE Comm. Magazine — Communications Standards Supplement, Dec. 2014, pp.10-15

SDN - standardization aspects

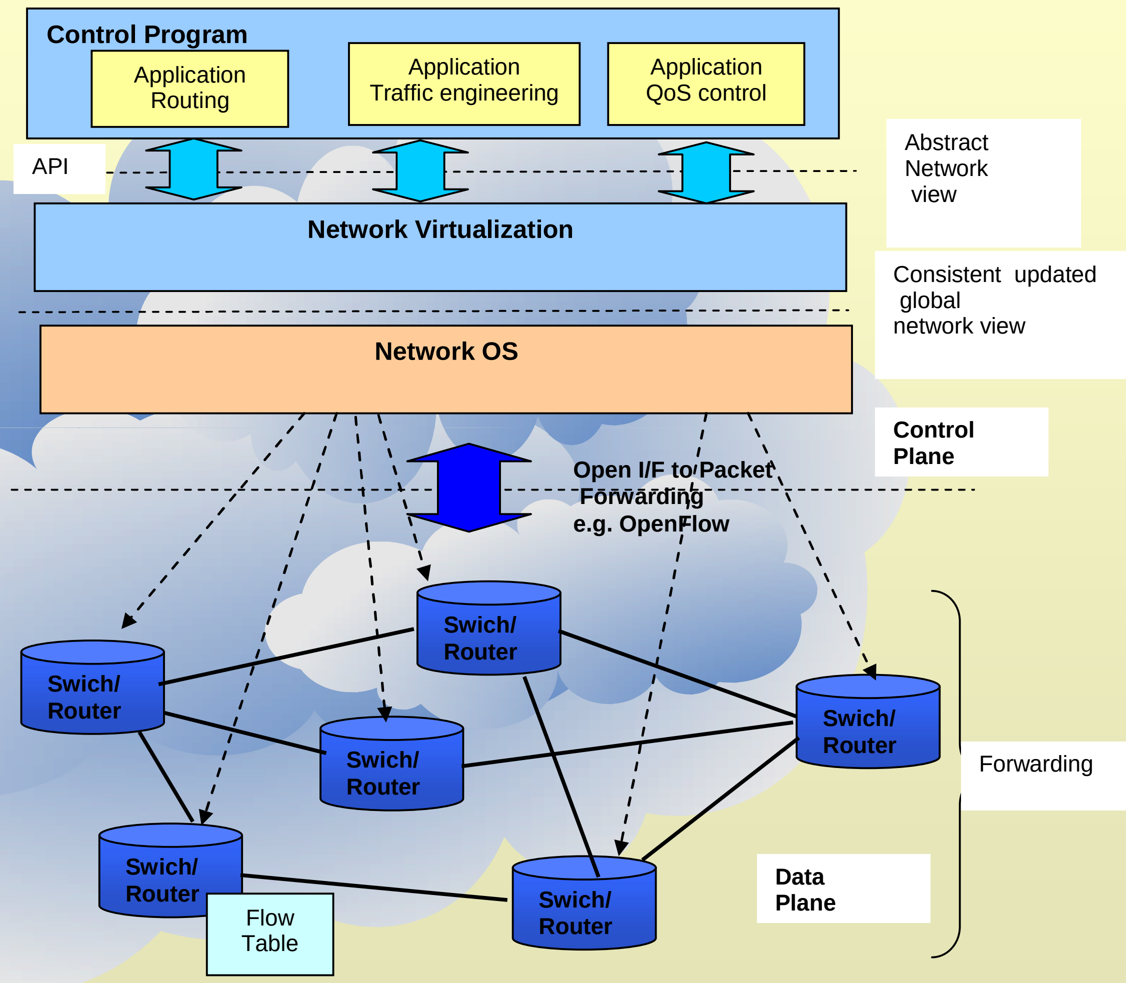
- **SDN main characteristics - (from Open Networking Foundation - ONF)**
  - **Separation of Control Plane from Data (Forwarding) Plane**
    - CPl/DPl Decoupling: Network control is directly programmable
  - **Centrally managed:** Network intelligence is (logically) centralized in SDN controllers
    - CPl maintains a global network view
    - Network appears to applications and policy engines as a single, logical switch
  - **Agility:** Abstracting CPl from DPl allow to dynamically adjust/adapt network-wide traffic flow conforming the current needs.
  - **SDN: based on open standards, vendor-neutral:**
    - SDN simplifies network design
    - Operation instructions provided by SDN controllers and not multiple, vendor-specific devices and protocols
    - The control programs do not depend on proprietary software
  - **Programmatic configuration**:
    - Better management : network can be quickly - configured, managed, secured, and optimized (in terms of resources) based on automated SDN programs

1. Software Defined Networking

- SDN Basic Architecture

- **Network OS:**
  - **Distributed system that creates a consistent, updated network view**
  - **Executed on servers (controllers) in the network**
  - **Examples: NOX, ONIX, HyperFlow, Floodlight, Trema, Kandoo, Beacon, Maestro,..**

- **Uses forwarding abstraction in order to:**
  - **Collect state information from FE**
  - **Generate commands to FE**



SDN - standardization aspects

- **SDN main standardization organizations**
  - OPEN NETWORKING FOUNDATION - ONF
  - EUROPEAN TELECOMMUNICATIONS STANDARDS INSTITUTE
    - INDUSTRY SPECIFICATION GROUP FOR NETWORK FUNCTION VIRTUALIZATION (ETSI NFV ISG)
  - ITU-T Study Group 13
  - INTERNET ENGINEERING TASK FORCE (IETF)s, IRTF
  - IEEE
  - OPEN DAYLIGHT (project)
  - ….

SDN - standardization aspects

- **OPEN NETWORKING FOUNDATION - ONF**
  - User-driven org. to promote and adopt the SDN through open standards development
  - Origin - Stanford University + OpenFlow protocol
  - 2014 - industry consortium with about 150 member companies
  - ONF is divided into 10 working groups (WG)
  -
  - **Extensibility WG** — defines and maintains the OpenFlow (OF) protocol specs
    - Earlier releases : OpenFlow 1.0 ,1.3, 1.4 spec.
    - Start work on OpenFlow 1.5.
    - The OF protocol specs – based on the the concept of *match-action-tables.*
      - The protocol allows the controller to specify entries for these tables
      - The semantics of matching fields continuously evolved

SDN - standardization aspects

- **OPEN NETWORKING FOUNDATION - ONF (cont'd)**
- **Configuration and Management WG**
- Defines and maintains protocols to manage OF switches.
  - Assumption on the common OF case; forwarder devices are strictly controlled via OpenFlow.
  - Earlier versions : 1.0, 1.1, 1.1.1 specs; working on 1.2.
  - The specs rely on the IETF *NetConf Configuration* protocol [RFC 6241] for its communication mechanism.
  - The specs use XML; the work was driven from the YANG work of IETF NetMOD WG

- **Architecture & Framework WG**
  - It describes SDN architecture and the role of the OpenFlow
  - It should be better correlated collaboration with other standards bodies

- **Forwarding Abstraction WG**
  - OpenFlow protocol uses a single abstraction for interacting with everything.
  - The Forwarding Abstraction work intends to enable pre-runtime description of the needed forwarder behavior

SDN - standardization aspects

- **OPEN NETWORKING FOUNDATION - ONF (cont'd)**

- **Optical Transport WG**
  - OpenFlow specs for control of optical transport networks
  - This work relies on ITU-T-developed models of optical transport networks to define the relevant components

- **Northbound Interface WG**
  - It defines the I/Fs of an OF-based SDN controller exposed to other policy and control elements e.g. operating at a higher level of abstraction

- **Wireless and Mobile WG (early stages)**
  - It extends the ONF-based work to wireless and mobile domains
  - Examples: *Evolved Packet Core* mobile processing (EPC), Mobile Backhaul, enterprise wireless networks

- **Migration WG**
  - It defines hybrid device operation (structuring and using a device which supports simultaneously OF and other operating paradigms)

SDN - standardization aspects

- **OPEN NETWORKING FOUNDATION - ONF** (cont'd)
  - **Other Activities in development**
  - **Testing and Interoperability WG** : test cases , interoperability events, certification aspects
  - **Marketing and Education WG:** white papers and solutions briefs, etc.
  - Work on defining mechanisms for service chaining (applying OpenFlow to layers 4–7).

SDN - standardization aspects

- **EUROPEAN TELECOMM. STANDARDS INSTITUTE INDUSTRY SPECIFICATION GROUP FOR NETWORK FUNCTION VIRTUALIZATION (ETSI NFV ISG)**
  - **ETSI - Operator driven organization (200 members)**
  - NFV ISG goals:
    - To define the reqs. and architecture for the **virtualization of network functions**
  - NFV is not strictly linked to SDN
  - However, SDN provides a powerful tool to enable many of the use cases of interest
  - **Structure: Technical Steering group + 6 WGs**
  - **Architecture of the Virtualization Infrastructure (NFV INF WG)**
    - - reference architecture for a virtualization infrastructure, and the Reference Points (RP) for components interconnection

SDN - standardization aspects

- **(ETSI NFV ISG) (cont'd)**

- **Management and Orchestration WG**
  - **-** It describes the deployment, instantiation, configuration, and management of network services based on the NFV
  - - integration : network service delivery – operational support systems (OSS) - business support systems (BSS)
  - The work sometimes overlaps with other standards

- **Software Architecture** WG
  - It defines
    - the reference SW arch. of network functions to be deployed
    - the detailed requirements of the interfaces and mechanisms defined by other WGs.

SDN - standardization aspects

- **(ETSI NFV ISG) (cont'd)**

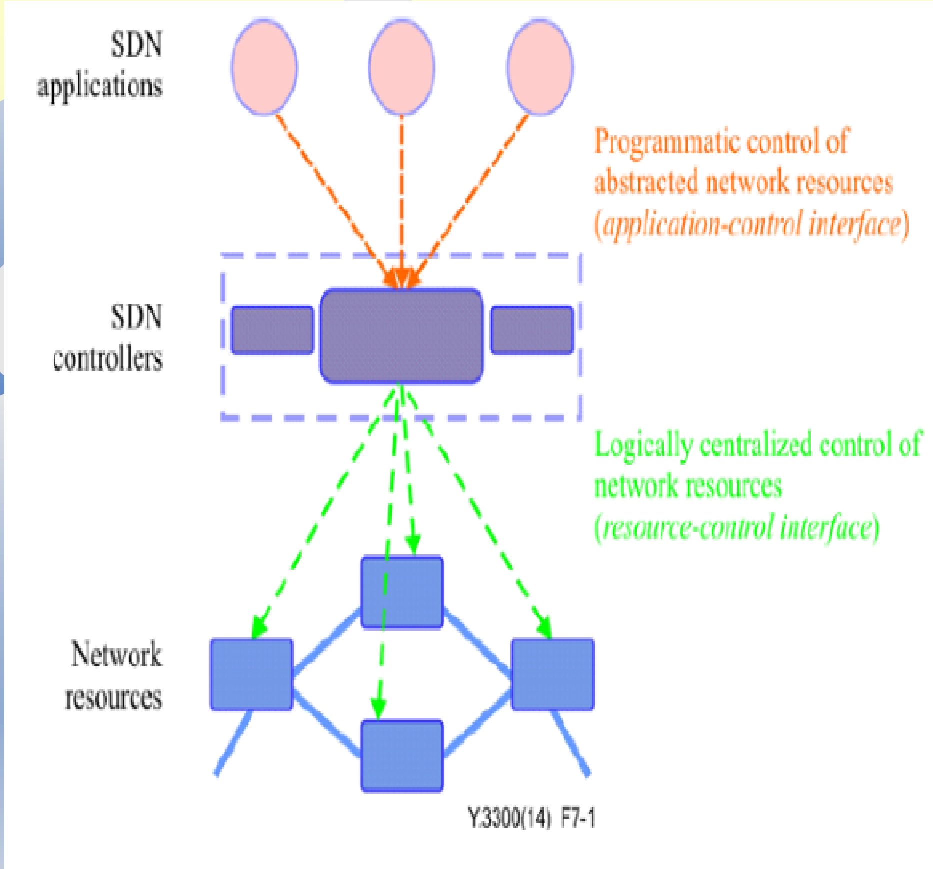
- **Reliability and Availability WG**
  - It defines the reliability and availability requirements in a NFV environment.
  - New approach needed if considering the replacement of traditional telecomm. equipment with more data-center-oriented equipment and with dynamic and virtualized instantiation of service functions

- **Security Expert WG**
  - security review and advices to the broader ETSI NFV activity.

- **Performance and Portability Expert WG**
  - The perf and the portability requirements in the new NFV environment changed significantly
  - This WG advises other WGs on perf. issues, constraints, capabilities, and potential advantages - of different architectural or deployment choices

SDN - standardization aspects

- **INTERNATIONAL TELECOMMUNICATIONS UNION TELECOMM. STD. SECTOR (ITU-T)- SG13**
  - Active in defining architectures and requirements for the use of SDN in transport networks.
  - These networks have important requirements different from other networks
  - Y.3300 Recommendation
    - They describe the fundamental SDN framework: definitions, objectives, high-level capabilities, requirements, and high-level architecture of the of SDN.



ITU-T SDN Architecture

SDN - standardization aspects

- **IETF**
- **Interface to Routing Systems (I2RS) WG**
  - It addresses a gap in the SDN. approach
  - The SDN controllers must interact with routing protocols, and SDN control must to be able to apply policy to actual routers.
  - Routers could be: integrated devices, or may themselves be decomposed; also they might be SDN capable
- I2RS general goal:
  - allow applications to learn from and request changes of the routing system.
- **Result expected:**
  - **classic distributed routing and centralized, policy- and application-driven SDN, can cooperate**

SDN - standardization aspects

- **IETF (cont'd)**
- **Interface to Routing Systems (I2RS) WG (cont'd)**

- Specifically, I2RS:
  - facilitates real-time or event-driven interaction with the routing system through a collection of protocol-based M&C I/Fs

  - allow information, policies, and operational parameters to be injected into and retrieved from the routing system
    while retaining data consistency and coherency across the
routers and routing infrastructure

- Open issue: compatibility/cooperation with
  - **ForCES,**
  - **NetConf with YANG,**
  - **RESTCong with YANG**

SDN - standardization aspects

- **IETF (cont'd)**
- **Service Function Chaining (SFC) WG**
  - standards for the DPI component of service chains → improve the traffic-direction problem
  - It defines an SFC architecture including the protocols (extensions) extensions to convey the SFC and SF Path information to nodes involved
  - It defining a range of carriage mechanisms, e.g., to allow the use
    - Layer 2 encapsulations (Eth., VLANs) to identify service paths, or
    - Intermediate such as as MPLS, or IP encapsulations
  - SFC does not mandate specific control mechanisms
    - However it is expected that dynamic SFC will use of SDN technologies to control and classify and forwarding functions in the service paths.
  - **Comments:**
    - SFC-WG- Work in progress
    - Still open issues: approaches, what to be defined in the arch. or left to implementation

SDN - standardization aspects

- **IEEE**
  - IEEE 802.1 began recently work on
    - 802.1CF (network reference model work) including defining interfaces with SDN.
    - Ongoing Work on enhancements to path control.
- The above are important components for industrial SDN and virtualization solutions
- The interaction between 802.1CF --- other SDN standards , is discussed between the OmniRAN Task Group and at ONF, IETF.
- New Research Group on Software Defined and Virtualized Wireless access

SDN - standardization aspects

- **OPEN DAYLIGHT**
  - Linux foundation → An open source SW activity
  - 2014: 36 member companies
  - Why open?

  - **General goal:**
  - for SDN and NFV early adoption, the industry would benefit of establishing an **open, reference framework** for programmability and control through an **open source SDN and NFV solution**
  - develop an SDN controller for a wide range of applications

  - **Aim** :
  - to maintain the flexibility and choice to allow organizations to deploy SDN and NFV at will,
    - but reducing risks of adopting early-stage technologies and integrating in existing infrastructure investments.

SDN - standardization aspects

- **OPEN DAYLIGHT (cont'd)**
- SW characteristics:
  - **JAVA,** supporting a wide range of I/Fs to applications, principally using REST technologies.
  - Includes a CLI to allow human interaction,
- It supports
  - JAVA RMI for closer coupling to the software.
  - a wide range of protocols for interacting with the network: *NetConf, SNMP, Open Virtual Switch Data Base (OVSDB), OpenFlow, BGP, Path Computation Engine Protocol (PCEP) , Locator/Identifier Separation Protocol (LISP).*
  - The arch. also explicitly allows adding new I/Fs, e.g. proprietary.
  - The system core is based on YANG models to describe the services, I/Fs, data storage.
  - This enables automatic code generation (not fully) and a common model-driven dispatch mechanism to support the flexibility needed.

SDN - standardization aspects

- **Interactions, collaboration, overlaps, conflicts …**
  - Facts:
    - (+) Related technologies, partially common goals, need for cooperation and synergy, ..
    - (+/-)Competition, different specific objectives, different communities, …
    - **ETSI NFV ---- ONF:** formal collaboration to enhance SDN support of NFV needs.
    - **ETSI NFV -----IETF**
      - NFV reqs : inputs the requirements work in the I2RS and SFC WGs
    - **ETSI ---- Open Daylight:** ETSI NFV defines PoC activities – some of them expected use of Open Daylight SW
    - Usually the other standards body collaborates with ETSI to analyze the needs and gaps in the current specifications.

SDN - standardization aspects

- **Interactions, collaboration, overlaps, conflicts …(cont'd)**
- ONF ----IETF
  - ONF progressed quickly but did not start a strong cooperation with IETF.
  - They founded a new standards body, and developed a specs focused on specific needs.
  - (+) specs developed quickly
  - (-) specs are rather narrow
    - -need more work to define how to utilize them in a broader area.
  - (-) difficulty in allowing the IETF to use ONF products.
  - (-) competition between ONF and other standard bodies- complicates the interactions…
- Example :ONF OFConfig protocol for managing OF switches.
  - (-) Currently the the market has failed to adopt this protocol.
  - More agreed is the proprietary protocol known as **OVSDB**
  - (-) Adopting YANG models for OF-Config- difficult

SDN - standardization aspects

- **Interaction, collaboration, overlaps, conflicts …(cont'd)**
- **ONF ----IETF (cont'd)**
  - RFC: 7047, The Open vSwitch Database Management Protocol, December 2013
  - Open vSwitch Database (OVSDB) is a management protocol in SDN environment.
  - OVSDB was created by the Nicira team and later acquired by VMware.
  - OVSDB is part of Open vSwitch (OVS) (feature-rich, open source virtual switch designed for Linux-based hypervisors).
  - In comparison with legacy SNMP,OVS created a modern, programmatic management protocol interface – and OVSDB can be a solution

  - Conclusion: a better cooperation ONF-IETF would be useful for everybody

SDN - standardization aspects

- **Interaction, collaboration, overlaps, conflicts …(cont'd)**
- **OPEN DAYLIGHT- interaction with standards**
  - Open Daylight includes people from the ONF and IETF
  - It built software using protocols from both ONF and IETF
  - This provided valuable feedback on :clear/not-clear, work/non-work useful/useless non-specified items in the standards,
  - Care should be taken – to not draw general conclusions from particular implementation- given some particular choices adopted in the implementation.
- **Other Industrial Fora involved in SDN specification activities**
  - BroadBand Forum (BBF)
  - Metro Ethernet Forum (MEF)
  - Optical Interface Forum (OIF).

SDN - standardization aspects

- **CONCLUSIONS**
  - The landscape of SDN standardization set of specs is broad, but contains duplicates (e.g. Forces/ONF)
  - More collaboration, is needed (no single org. can do all tasks)

  - **There are proposals**
    - to more clearly define the responsibilities and consider previous work when a std. body starts new std. effort
    - to allow participation to multiple groups
    - improve the interoperability
    - avoid the tendency of one body to expand into adjacent spaces of others
  - Emergence of open-source software, also has some own challenges.
    - Need that standards bodies and open-source communities cooperate better
    - Note that implementations, and standards are not the same thing

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- Thank you !

SDN - standardization aspects

References

- [1] J.M. Halpern, "Standards Collision around SDN", IEEE Comm. Magazine, Comm Standards, Dec. 2014, pp.10-15
- [2] J. Halpern and J. Hadi Salim, RFC 5812 "Forwarding and Control Element Separation (ForCES) Forwarding Element Model,"
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- [3] Open Networking Foundation "Software-Defined Networking (SDN) Definition,"
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- [4] R. Enns *et al*., RFC 6241 "Network Configuration Protocol (NETCONF),"
  - http://www.rfc-editor.org/rfc/rfc6241.txt.
- [5] M. Bjorklund, RFC 6020 "YANG — A Data Modeling Language for the Network Configuration Protocol (NETCONF),"
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- [6] A. Doria *et al.*, Editors, RFC 5810 "Forwarding and Control Element Separation (ForCES) Protocol Specification,"
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SDN - standardization aspects

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- [7] IETF Charter for the I2RS Working Group,
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- [8] ETSI ISG NFV “Our Role & Activities,”
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- [9] Open Daylight “Why Opendaylight,”
  - http://www.opendaylight.org/project/why-opendaylight.
- [10] ITU-T, SG13 Joint Coordination Activity On Software Defined Networks, JCA-SDN-D-001 , Geneva, Nov 2014
- [11] ITU-T SERIES Y 3300: GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS AND NEXT-GENERATION NETWORKS: Framework of software-defined networking, June 2014

Distributed System Behavior Modeling with Ontologies, Rules, and Message Passing Mechanisms

By

Mark A. Austin and Parastoo Delgoshaei

Institute for Systems Research, University of Maryland, College Park

Panel on New Directions on Networks and Systems Design, ICONS 2015, April 23, 2015

Motivation

Societal-Scale Infrastructures: Spatially distributed network structures, concurrent subsystem-level behaviors, distributed control and decision making, and interdependencies among multiple domains that are not always well understood.

New York City Subway System:

"When excessive water enters the subway, the system must be shut down before the water comes into contact with the third rail. The 600 volts running through the rail can cause the water to boil and set debris on fire. Water also short-circuits electrical signals and switches."

Washington DC Metro:

"Metro may suspend aboveground rail service in a major snowstorm (eight inches) and serve only underground stations."

Source: [http://www.wmata.com/getting_around/safety_security/snowmap.cfm]

Shady Grove Incident 1996 Blizzard

Source: [http://en.wikipedia.org/wiki/Incidents_on_the_Washington_Metro]

Problem Statement

Characteristics of Distributed Systems:

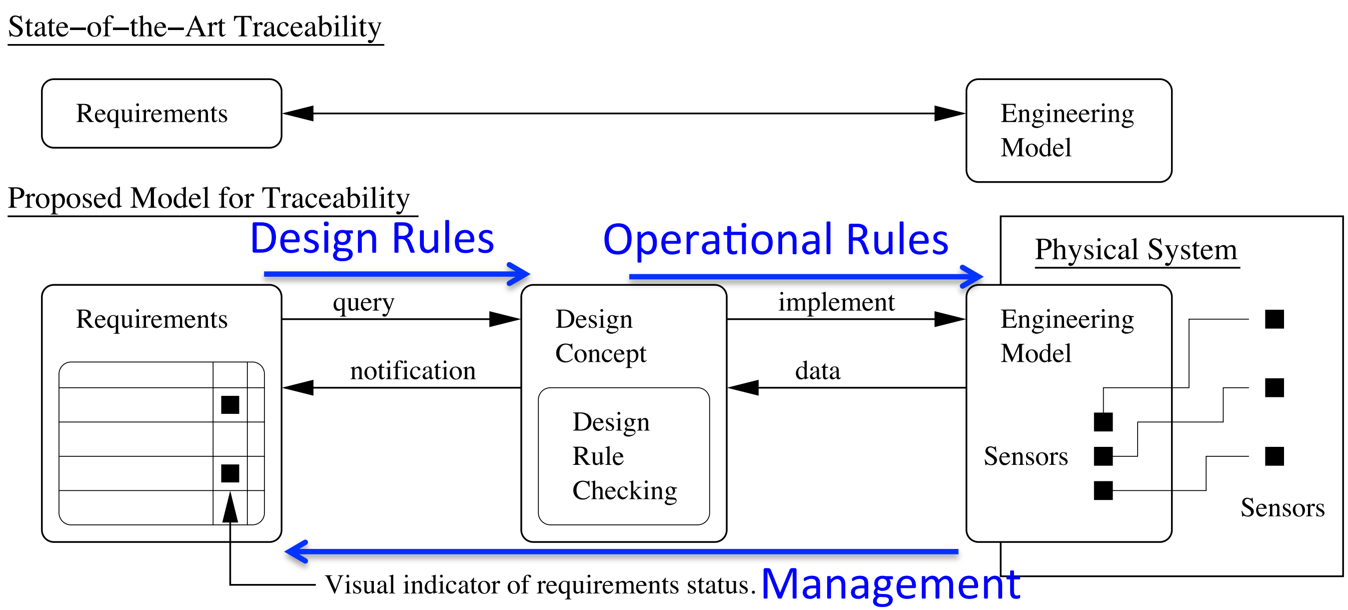
- Networks are heterogeneous, multiple layers, interwoven, dynamic.
- Disciplines want to operate independently in their domain.
- Achieving target levels of performance and correctness of functionality requires that disciplines coordinate activities at key points in the system operation.
- Disturbance in one system can impact other networks in ways that are unexpected, undesirable, and very costly.
- Communication and information exchange establishes common knowledge among the decision making agents. Better system management!

Key challenge in Decentralized System Control:

- How should decision makers cooperate to achieve system-wide performance and management objectives?

Background: Traceability Mechanisms

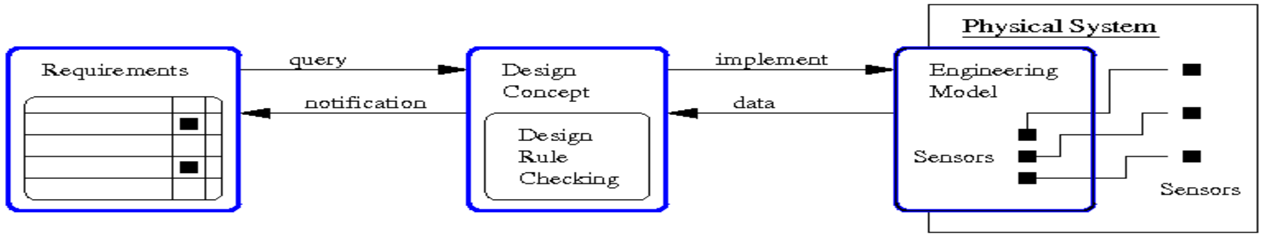
New idea (2005): Ontology-enabled Traceability Mechanisms

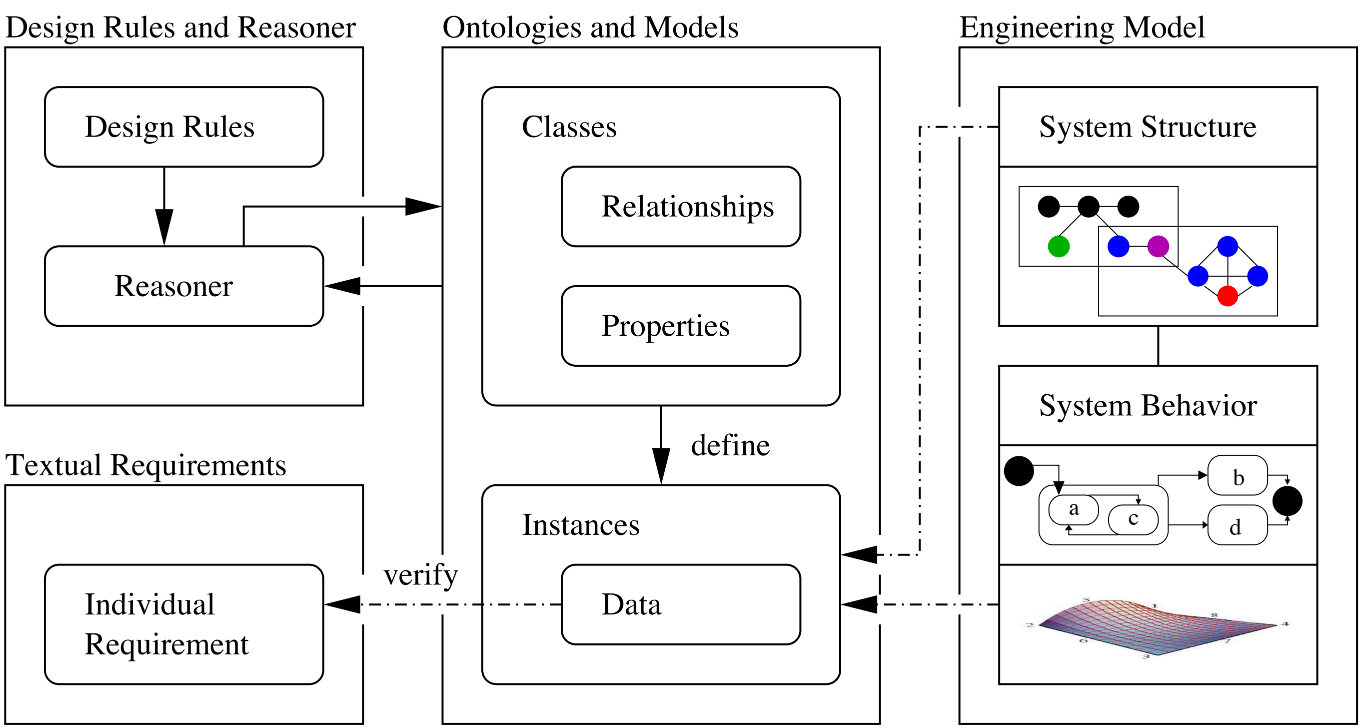


Approach: Requirements are satisfied through implementation of design concepts. Now traceability pathways are threaded through design concepts.

Key Benefit: Rule checking can be attached to "design concepts" (ontology), therefore, we have a pathway for early verification.

Background: Implementation





Remarks

System structures are modeled as networks and composite hierarchies of components.

Behaviors will be associated with components.

Discrete behavior will be modeled with finite state machines.

Continuous behavior will be represented by partial differential equations.

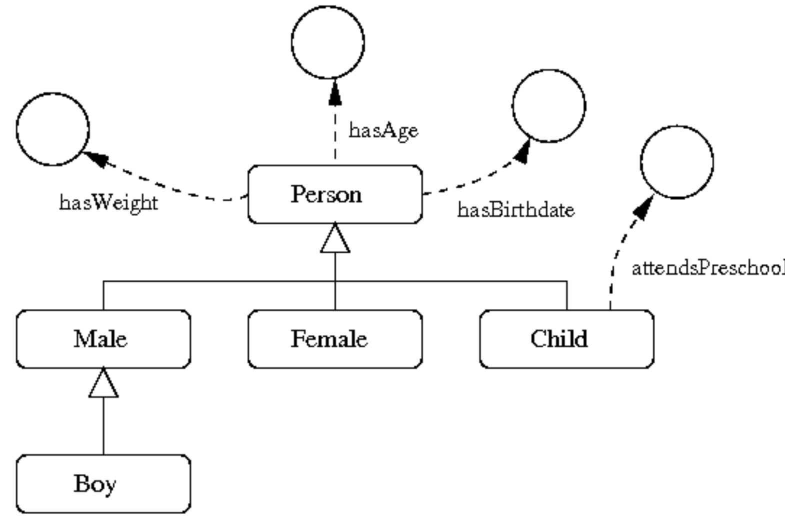
Ontology and Rule-Based Reasoning

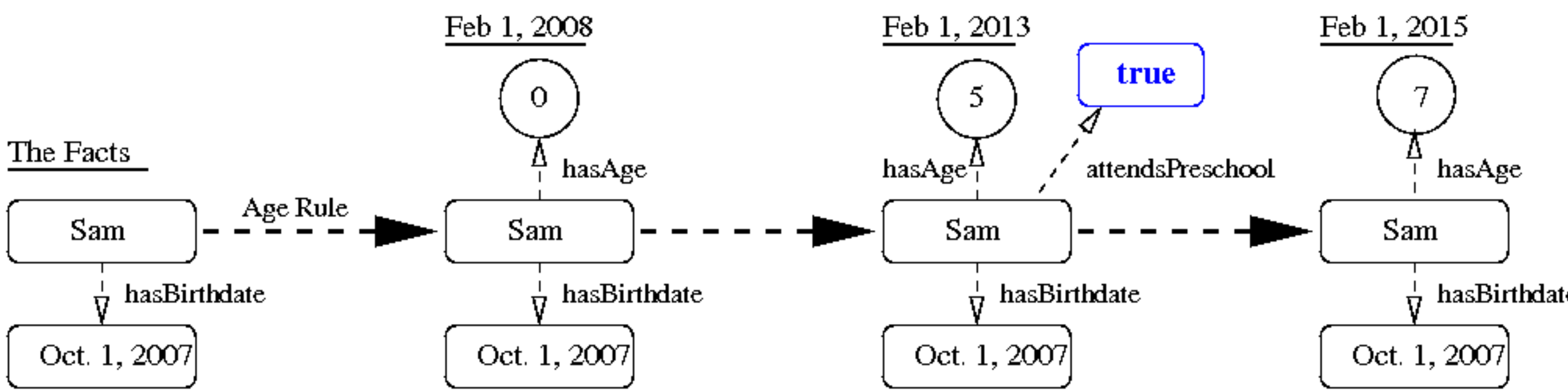
Fact. Sam is a boy. He was born October 1, 2007.

Rule 1: For a given date of birth, a built-in function getAge() computes a person's age.

Rule 2: A child is a person with age < 18.

Rule 3: Children who are age 5 attend preschool.



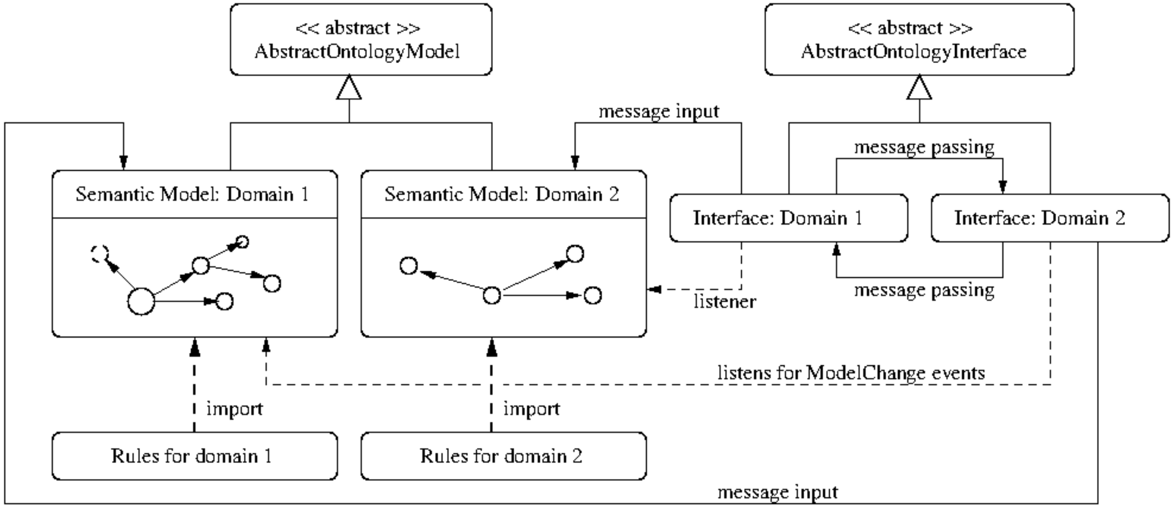


Project Scope and Prototype Solution

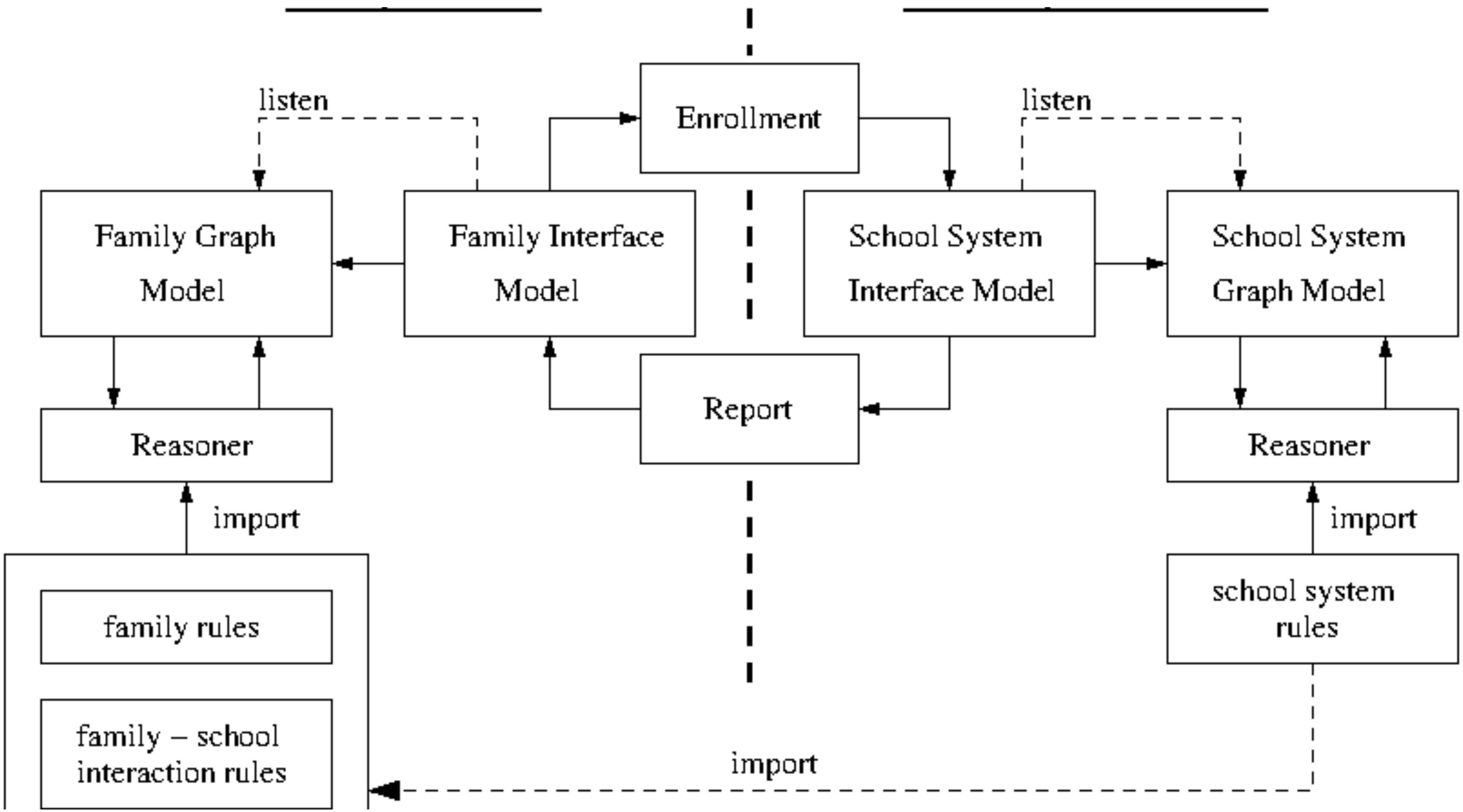
Project Scope: Create a network of connected domain-specific ontologies and associated rules that communicate via message passing.

Prototype Solution: Develop abstract ontology interfaces implemented by domain specific semantic models that:

- Listen for changes to the semantic domain graph
- Forward the essential details of the change to interfaces that have registered interest in receiving notification of such changes.
- Listen for incoming messages from external semantic models.



Case Study 1. Family-School System



Case Study 1. Family-System Jena Rules

```
// Rule 01: Propagate class hierarchy relationships ....

[ rdfs01: (?x rdfs:subClassOf ?y), notEqual(?x,?y) -> [ (?a rdf:type ?y) <- (?a rdf:type ?x)] ]

// Rule 03: Compute and store the age of a person ....

[ Age01: (?x rdf:type af:Person) (?x af:hasBirthDate ?y) getAge(?y,?z) -> (?x af:hasAge ?z) ]
```

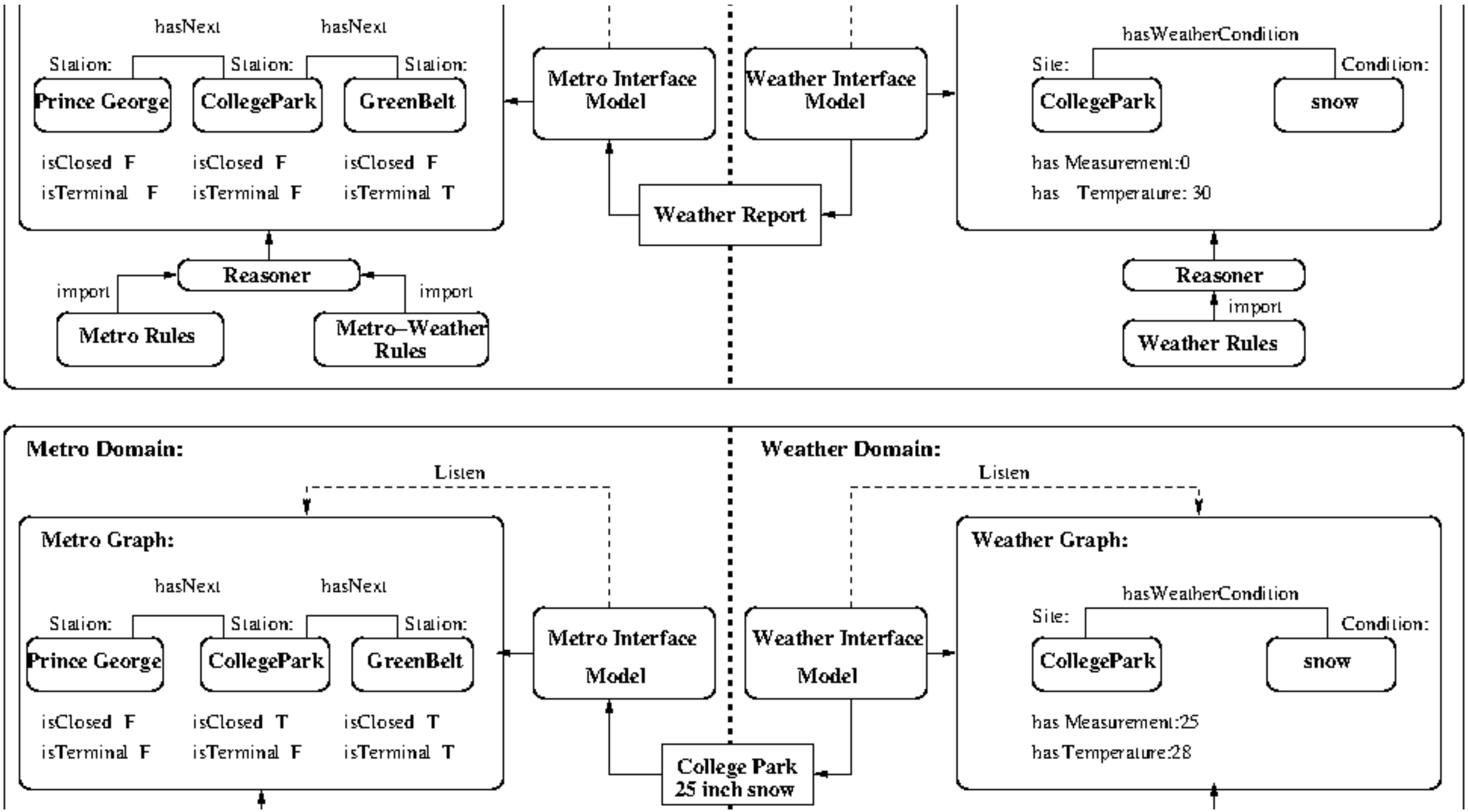
Abbreviated Family-School Interaction Rules

```
@prefix af:  <http://austin.org/family#>.

// Rules 02: Children aged 6 through 18 attend regular school ....

[ School01: (?x rdf:type af:Person) (?x af:hasBirthDate ?a)
            getAge(?a,?b) ge(?b, 6) le(?b, 18) -> (?x af:attendsSchool af:True) ]
```

Abbreviated School Rules

```
@prefix af:  <http://austin.org/school#>.

// Rules 01: Elementary school rules ...
```

Case Study 2. Weather-Metro System



Case Study 2. Weather-Metro Rules

```
[ rule02: (?s1 rdf:type tr:Station) (?s2 rdf:type tr:Station) notEqual(?s1,?s2)
          (?s1 tr:hasNext ?s2) noValue(?s1 tr:hasPrevious ?s2) -> (?s2 tr:hasPrevious ?s1)]

// rule03: If one station Closed, close the next station

[ rule03: (?s1 rdf:type tr:Station ) (?s2 rdf:type tr:Station) (?s1 tr:hasNext ?s2)
          (?s1 tr:isClosed "true"^^xs:boolean) -> (?s2 tr:isClosed "true"^^xs:boolean)]
```

Abbreviated Weather-Metro Interaction Rules

```
@prefix tr:  <http://transportation.org/metro#>.

// rule01: Shut down the station affected by snow

[ rule01: (?s1 rdf:type tr:Station) (?s1 tr:hasSnowEvent ?m)
          greaterThan(?m,10) -> (?s1 tr:isClosed "true"^^xs:boolean)]
```

Abbreviated Weather Rules

Challenges Moving Forward ….

This work is just a stepping-stone!

- Provide the basics for studying behaviour of interconnected complex systems.
- Predict cascading system failures that occur as the result of extreme external events.

Future work will investigate :

- Opportunities for linking discrete-continuous behaviours through the use of libraries of built-in functions within the Jena rules.
- Understand network properties: stability, scalability, validation of rule-based behaviors.
- To what extent can we prove things ?? …

Panel on ICN and ICONS
“New Directions on Networks and Systems Design”

April 18-24, 2015 @ Barcelona, Spain

Embedding Laws of Requisites in the Net-centric Design of Complex Systems

Roberto Legaspi, PhD

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Transdisciplinary Research Integration Center

Research Organization of Information and Systems
The Institute of Statistical Mathematics

An Illustration of Butterfly Effect

Hurricane Katrina – US, Aug 2005

Disruption of 95% of oil production in the Gulf

Surge in price of American gasoline

Spike of investments in ethanol - corn is main ingredient

Price of tortilla increased hundred-folds

"Tortilla Riot" – Mexico, Jan 2007

More details in Zolli, A. & Healy, A.M. (2012). Resilience: Why Things Bounce Back? New York, NY: Free Press.

Argument and Motivation

Models

Linear, incomplete and fragmented knowledge

We focus on the computable even though we are cognizant of the non-computable aspects. (Carpenter et al., 2009)

We believe in the “dominant” models. (Carpenter et al., 2009)

Our models do NOT demonstrate the critical links and interdependencies that mesh our systems.

Carpenter, S. R., Folke, C. , Scheffer, M. & Westley, F. (2009). Resilience: Accounting for the noncomputable. Ecology and Society, vol. 14, no. 1, article 13.

Approach: Laws of Requisites in SysDesign

- ## Law of Requisite Complexity

  The complexity of the system must be commensurate to the complexity of the environment in which it is embedded.

  McKelvey, B. & Boisot, M. (2009). Redefining strategic foresight: 'Fast' and 'far' sight via complexity science. In: L.A. Costanzo and R.B. MacKay (eds) Handbook of Research on Strategy and Foresight. Cheltenham, UK: Elgar, pp. 15–47

- ## Law of Requisite Variety

  The larger the variety of actions available to a control system, the larger the variety of perturbations it is able to compensate.

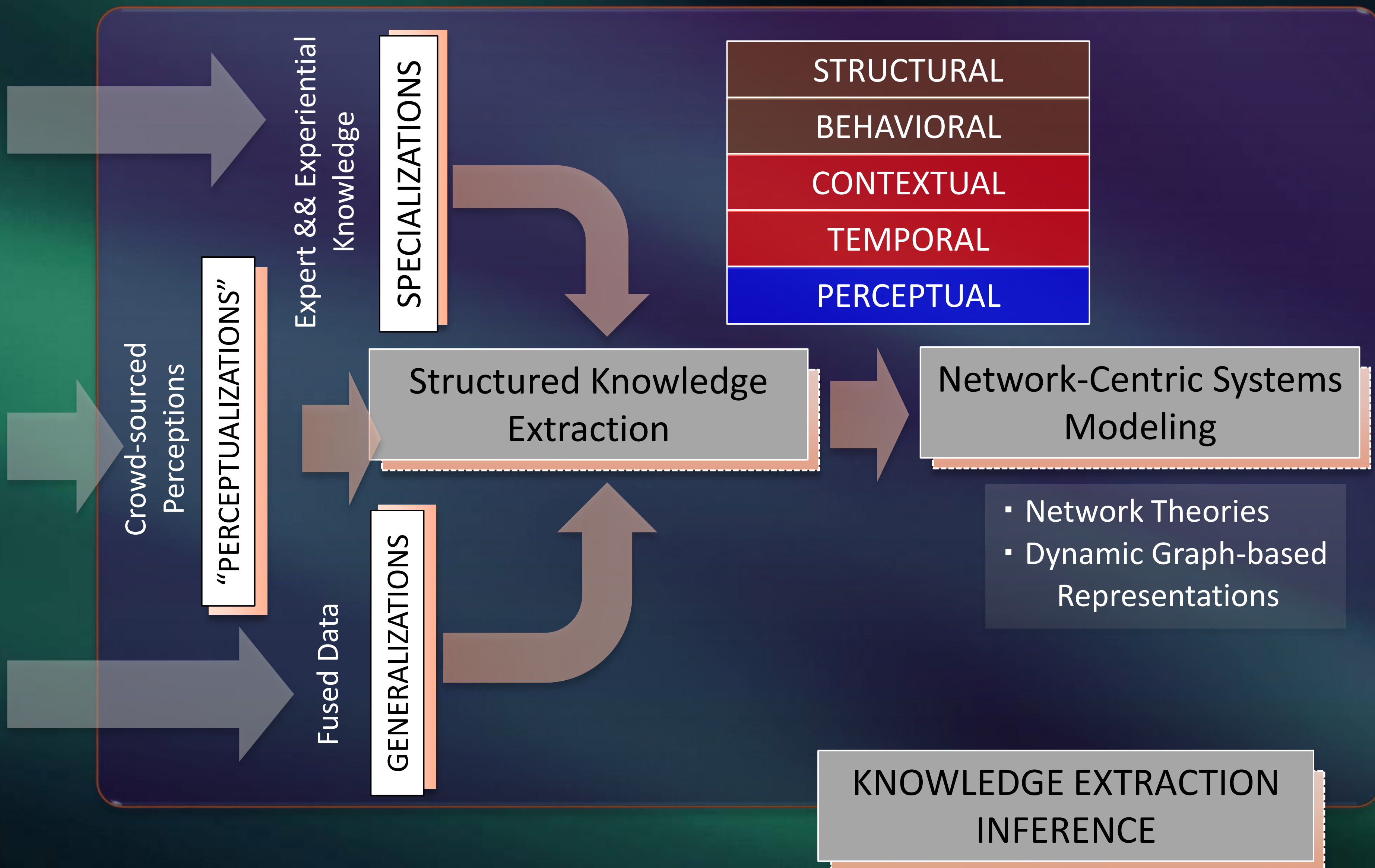
  Ashby, R.W. (1956) An Introduction to Cybernetics. London: Methuen.

- ## Law of Requisite Knowledge

  In order to adequately compensate perturbations, a control system must "know" which action to select from the variety of available actions.

  Heylighen F. (1992): " Principles of Systems and Cybernetics: An evolutionary perspective ", In: R. Trappl (ed.) Cybernetics and Systems '92. World Science, Singapore, pp. 3-10.

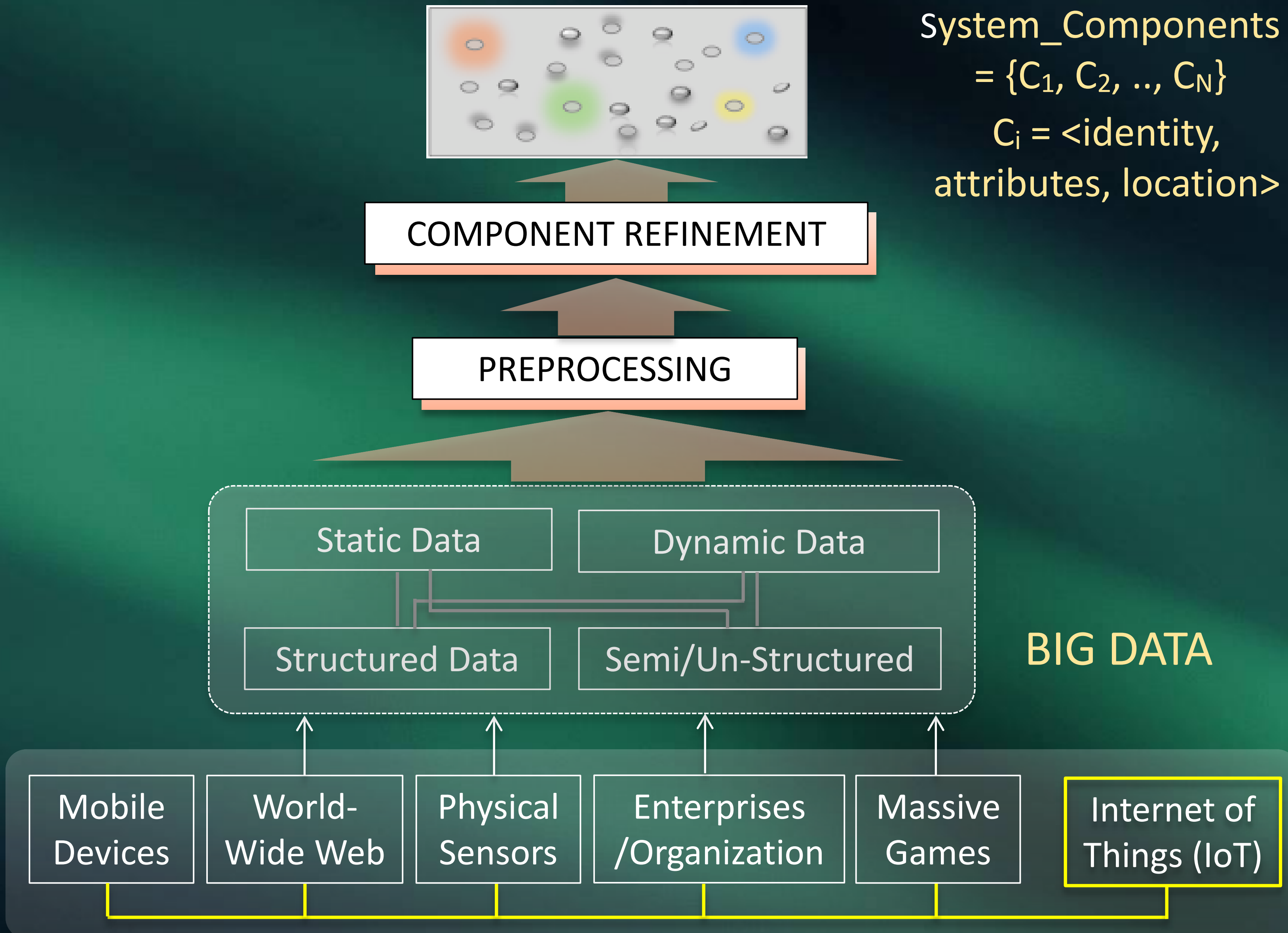
Multi-level Framework



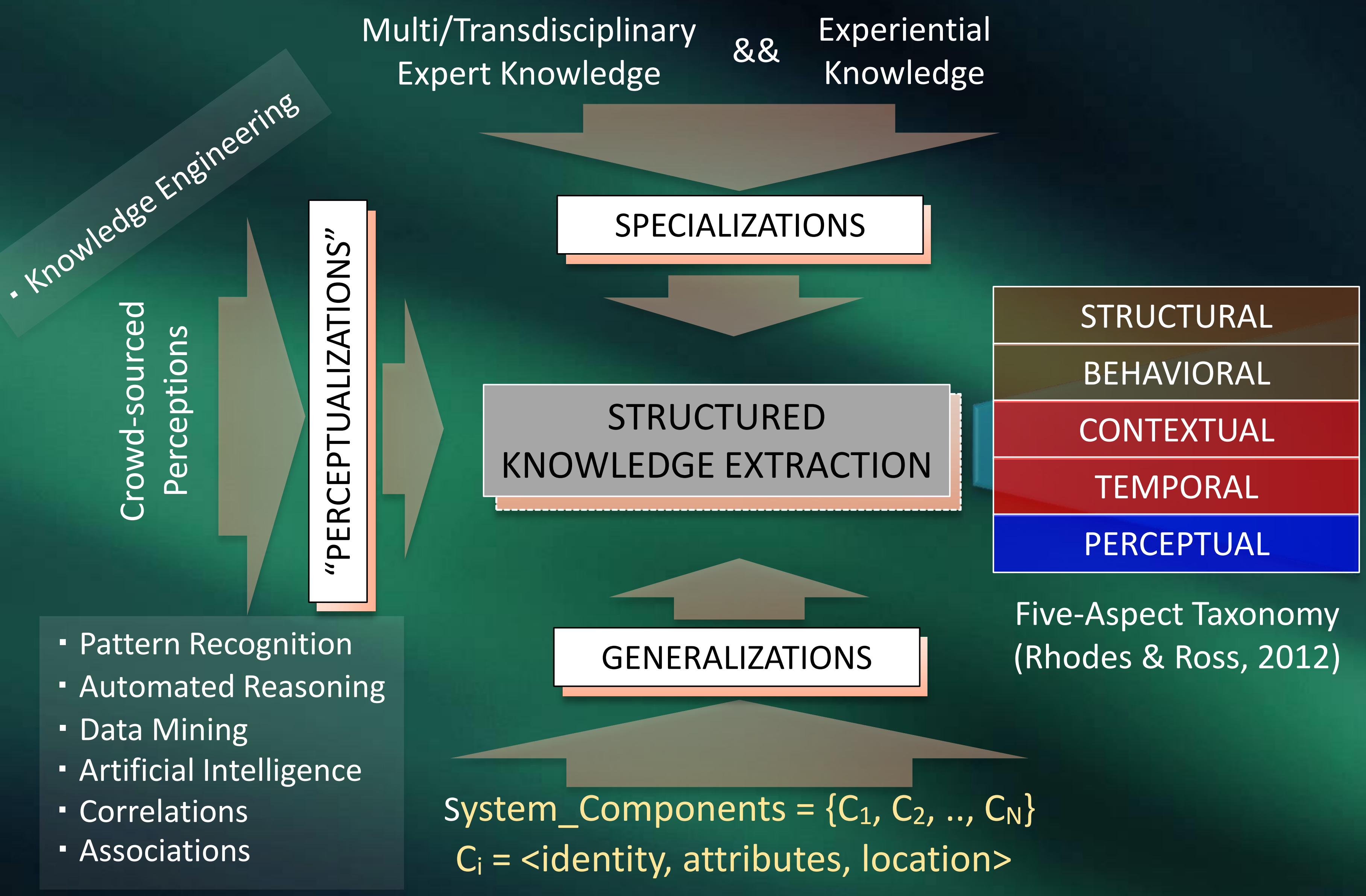
Level 0 Embedding – Data Fusion

System_Components = $\{C_1, C_2, .., C_N\}$

C_i = <identity, attributes, location>



Level 1 Embedding: Knowledge Fusion

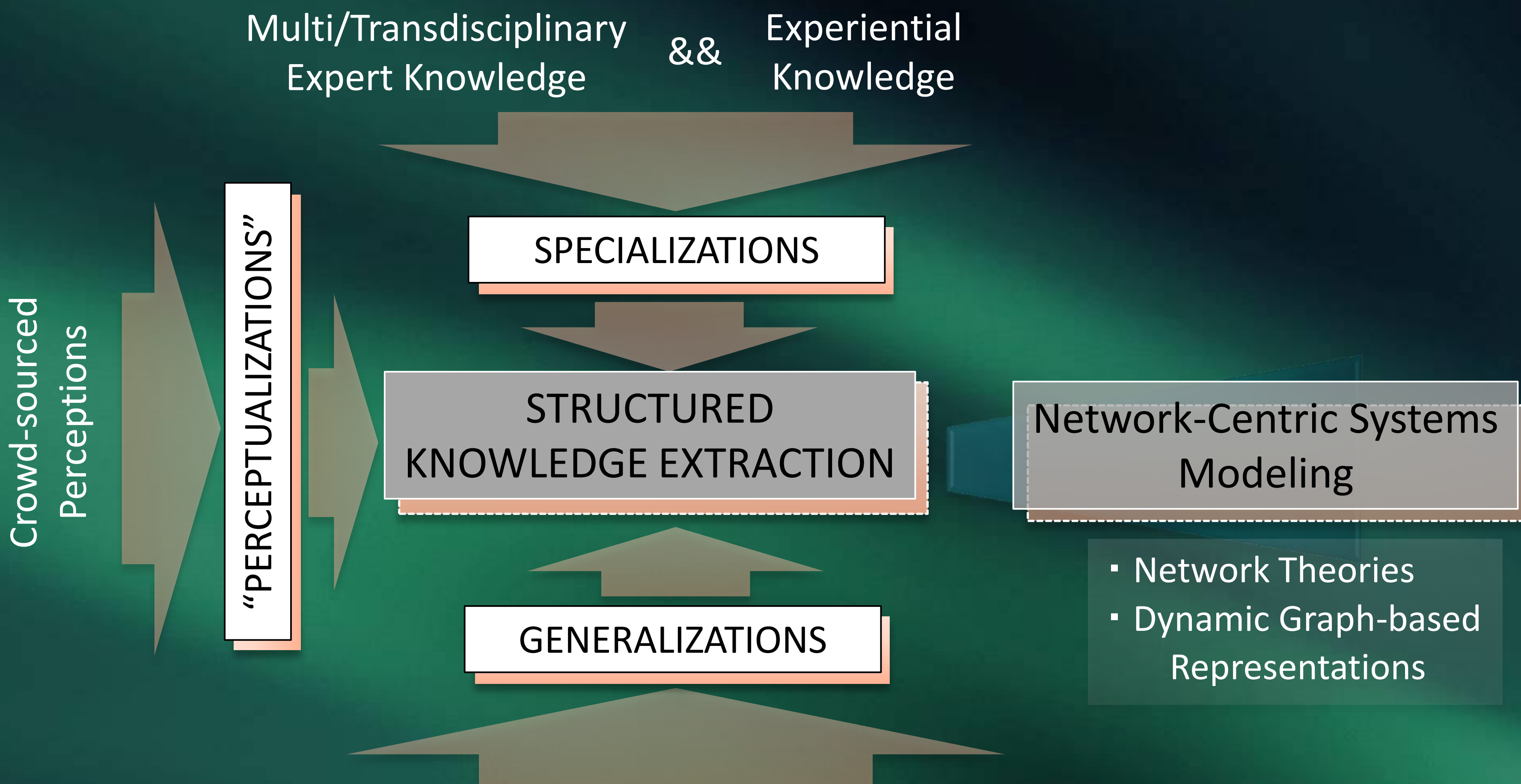


Level 1 Embedding: Knowledge Fusion

STRUCTURAL	• heterogeneous/homogenous components/constituents • elaborate networks, loose and tight couplings • layers, vertical/horizontal structures, multiplicity of scales
BEHAVIORAL	• variance in response to stimuli • unpredictable behavior of technological connections • emergent social network behavior
CONTEXTUAL	• many complexities and uncertainties in system context • political, economic, environmental, threat, market factors • stakeholder needs profile and overall worldview
TEMPORAL	• decoupled acquisition phases and context shifts • systems with long lifespan and changing characteristics • time-based system properties (flexibility, survivability, etc.)
PERCEPTUAL	• many stakeholder preferences to consider • perception of value shifts changes with context shifts • cognitive constraints and biases

Refer: Rhodes, D.H. & Ross, A.M. (2010) Shaping Socio-technical System Innovation Strategies Using a Five Aspects Taxonomy

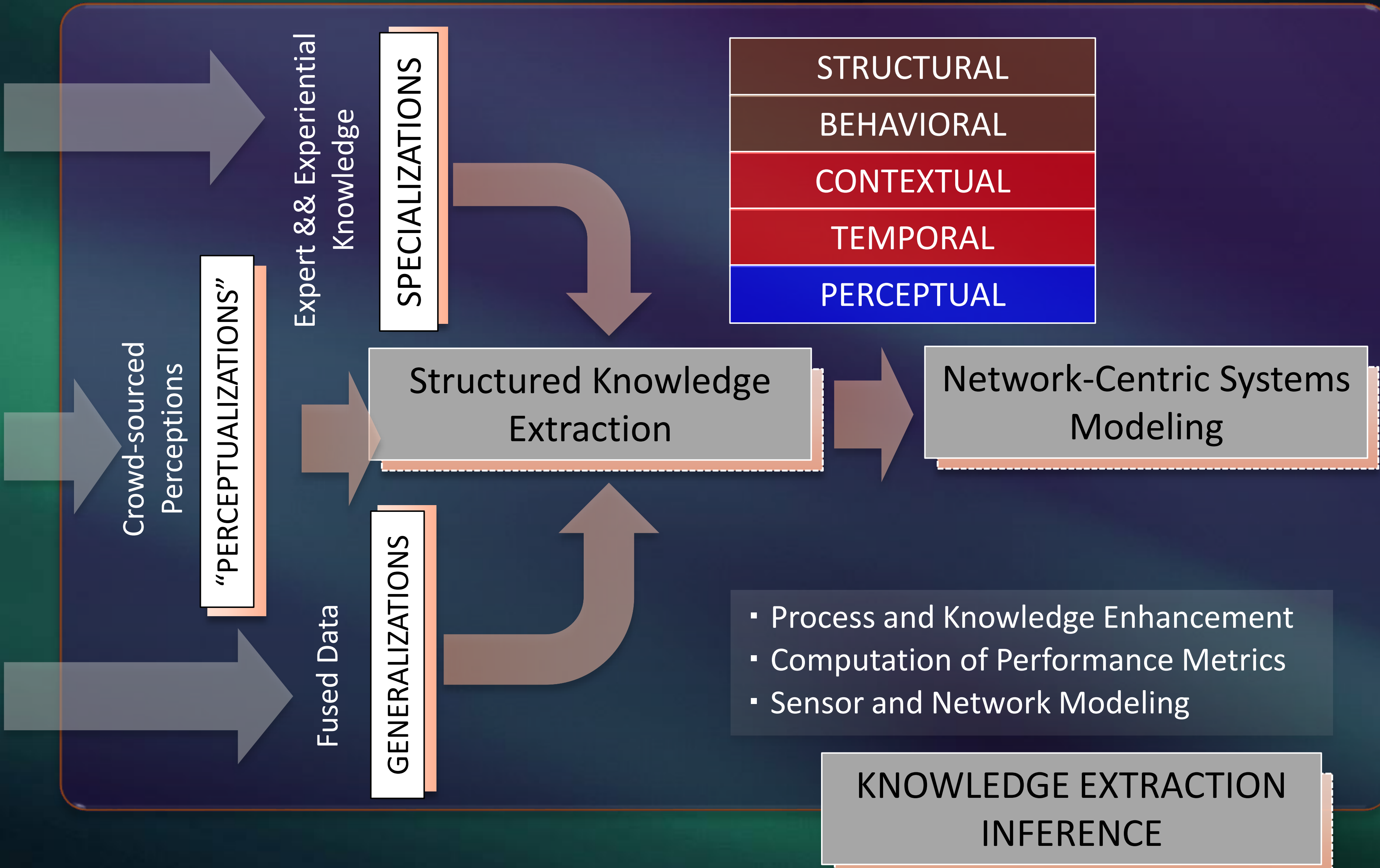
Level 1 Embedding: Knowledge Fusion



System_Components = $\{C_1, C_2, .., C_N\}$

C_i = <identity, attributes, location>

Level 2 Embedding: Incremental Learning



Viability and Challenges

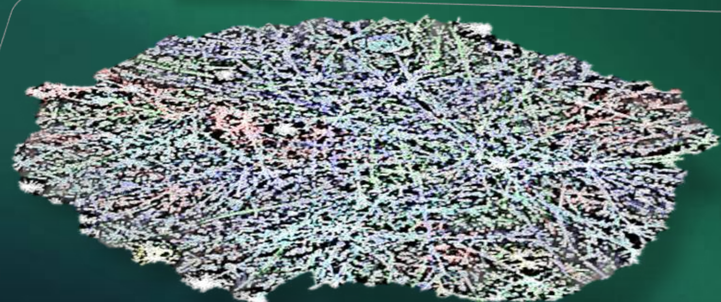
PRESCRIPTIVE Analyses

PREDICTIVE Analyses

DESCRIPTIVE Analyses

- Agent-based Simulations
- Network and Graph Theories
- Data/Relations Mining

- Develop a theory of lever point (John H. Holland)
- Develop a theory of system boundary, on openness and modularity, and their trade-offs (Carpenter et al., 2013)
- Develop a theory of creative chaos



Web of Integrated Knowledge

STRUCTURAL

BEHAVIORAL

CONTEXTUAL

TEMPORAL

PERCEPTUAL

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How security shapes system design?

e-banking example

ICONS 2015, Barcelona, Spain

e-banking security

- very secure core banking system
- the security of a user station and proper authentication are the most important issues
- several techniques for authentication exists:
  - usually login/password to access online banking website
  - transaction confirmation:
    - most popular (*in Poland*) SMS (text) codes
    - one-time codes (from printed list) (old solution)
    - token
- Other cryptographic techniques like smart card based authentication could be used

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e-banking security issues

Case 1:

- Malicious software created to attack only a small number of companies will not be detected by antivirus software
- The malware changes user view
- Several known attacks

Case 2:

- Mobile banking – sms codes go to the same device (smartphone) from which they were requested, they do not increase security any more

Case 3:

- Mobile banking: payments with codes (e.g., 6 digits, valid 120s) – simple and secure system design, unless the smartphone can be trusted…

Case 4:

- Contactless card payments, offline without PIN verification, (usually, max 3 transaction for max 25 euros) (*in Poland few years ago limits where not configured properly by banks*)

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e-banking system challanges

- It is possible to make more secure systems for consumers, which are still functional enough?

- The system for banks are designed and implemented using one of the methodologies which involves risks analysis
- Two parties are using the system:
  - a bank
  - a consumer
  - Which party has more risks mitigated?

- Are there legal instruments that can directly move more risks to a bank?

- Better security for a consumers would cost more?

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Embedded Systems Innovation BY TNO

Model-based design of distributed systems

Jacques Verriet - TNO-ESI

April 23, 2015

Networked system characteristics

- Distributed systems
  - thousands of (hardware and software) components
- Few component types
  - devices
  - control components
- Many different configurations
  - topology
  - control behaviour
  - network topology

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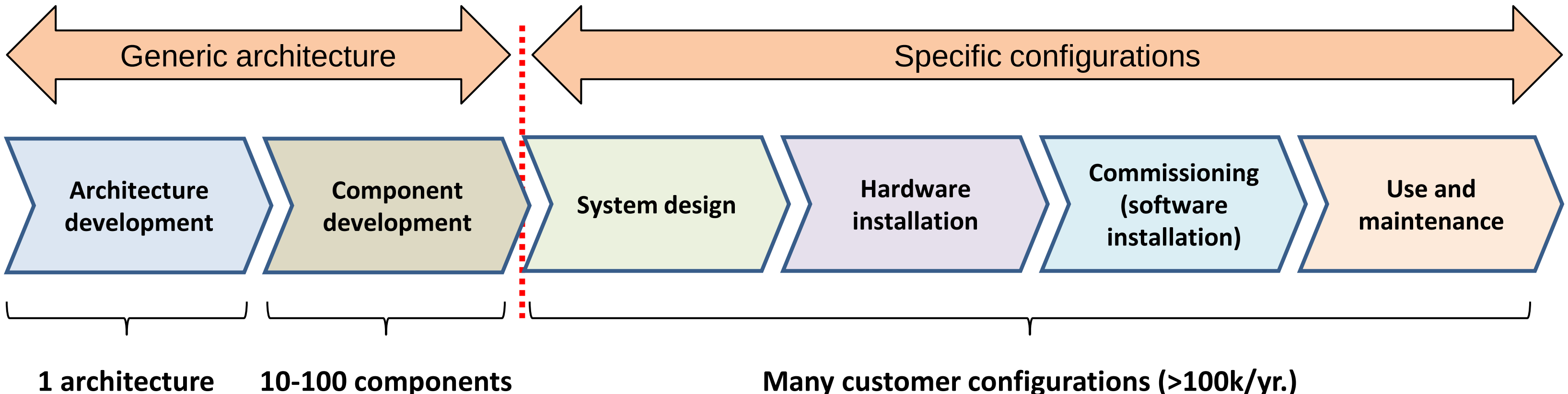
Design challenge

- To guarantee correct system behaviour, one would like to
  - evaluate all possible executions
  - of all possible system configurations

- Approach: Analysis models with the same configurability possibilities as the distributed systems



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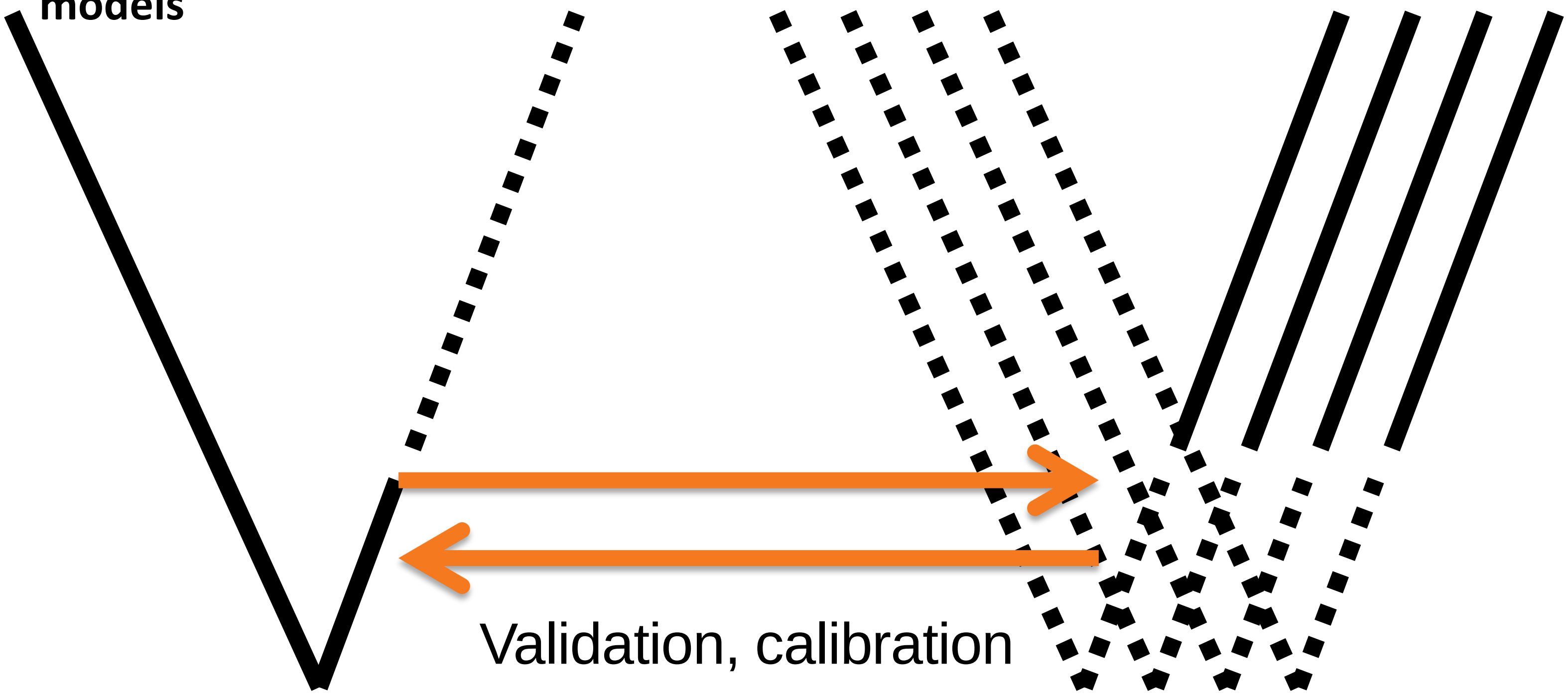
Generic architecture vs. specific configurations

Reference architecture:

- **Components, interfaces, protocols**
- **Processes, methods, tools, models**

Many system configurations (built from/using generic components, processes …)



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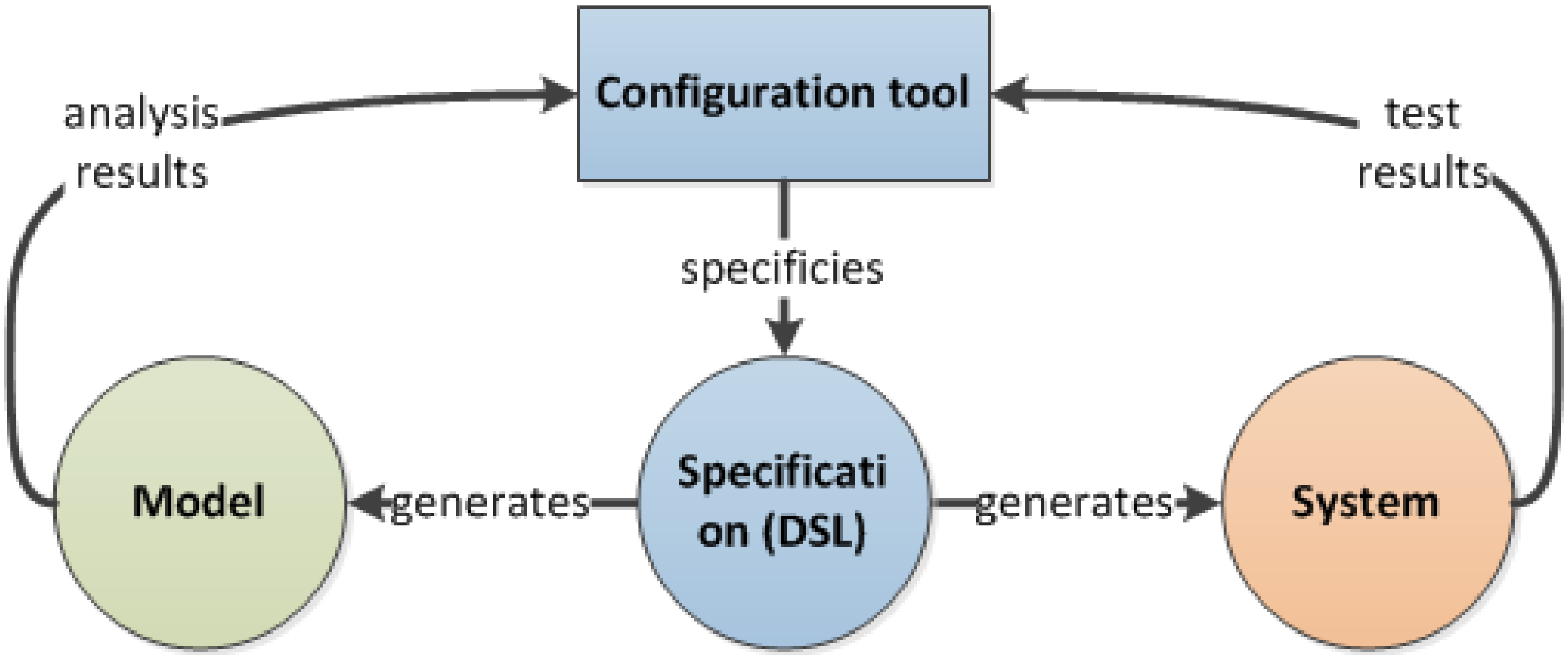
System and mode configurability



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Approach: Use system configurability

- Analysis models with the same configurability possibilities as the distributed systems

- Three examples
  - Example 1: Transport simulation
  - Example 2: Warehouse control simulation
  - Example 3: Lighting control model checking

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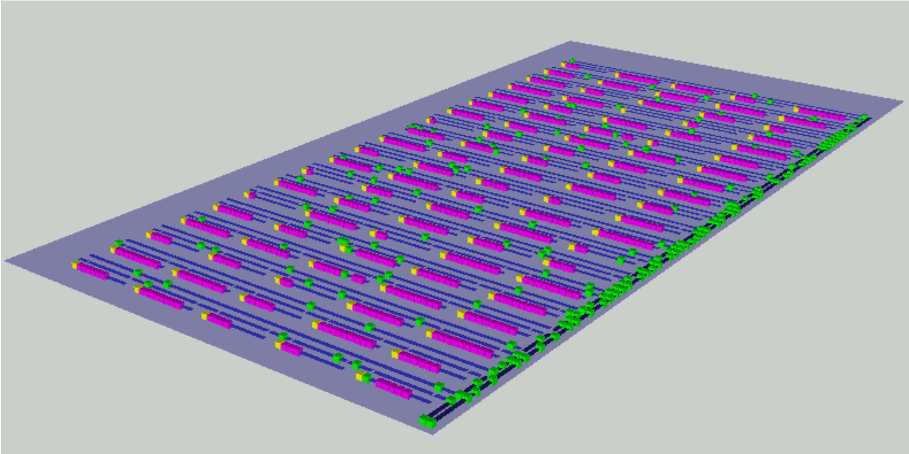
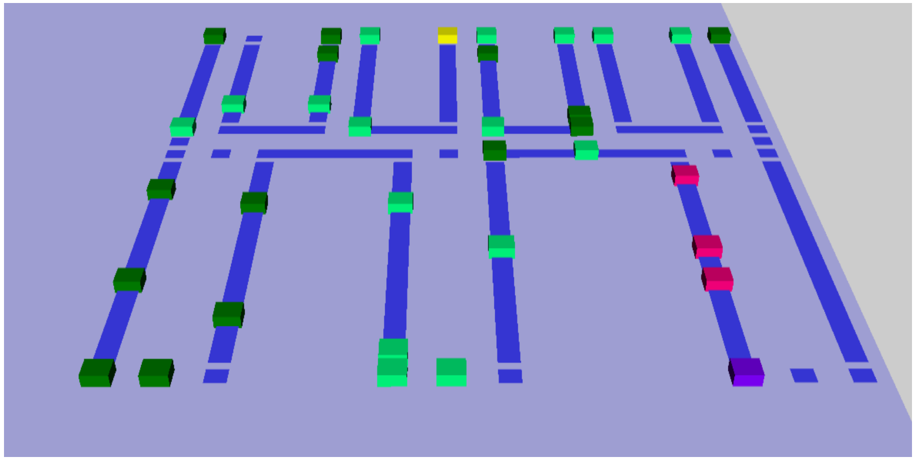
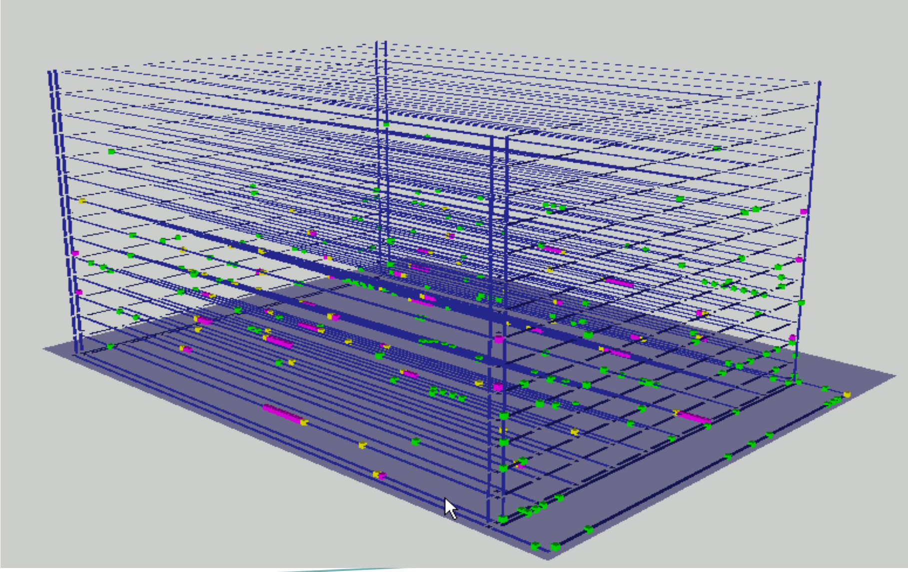
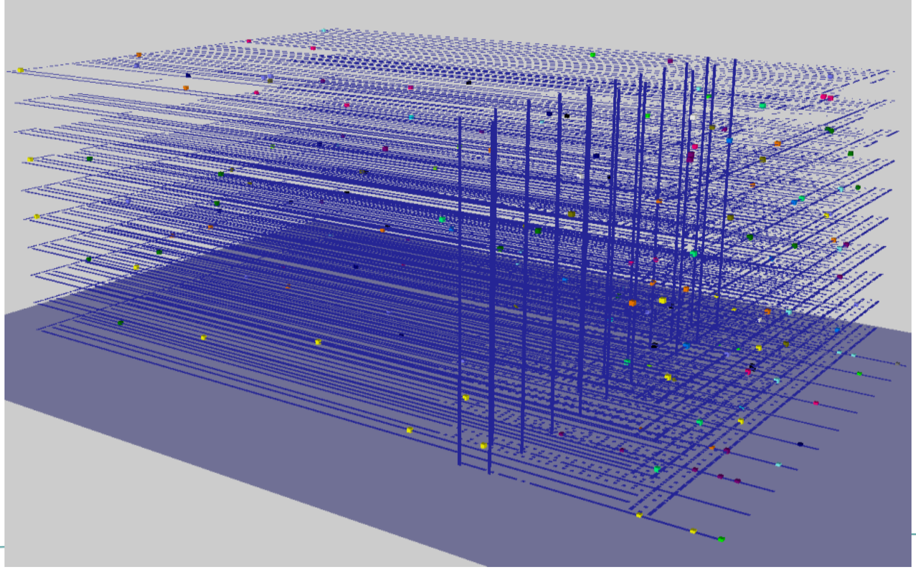
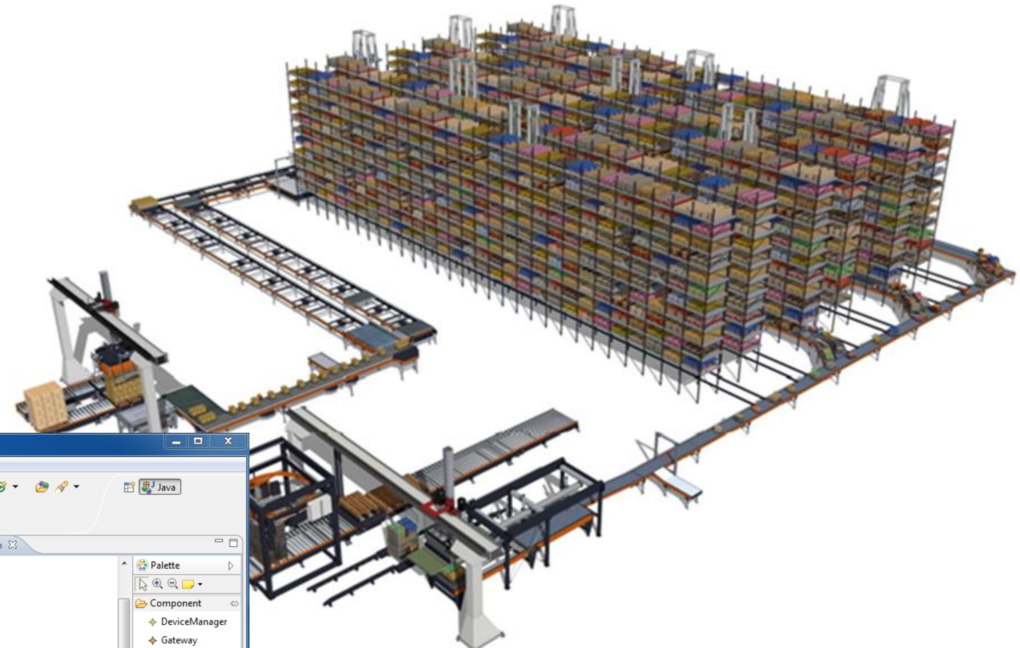
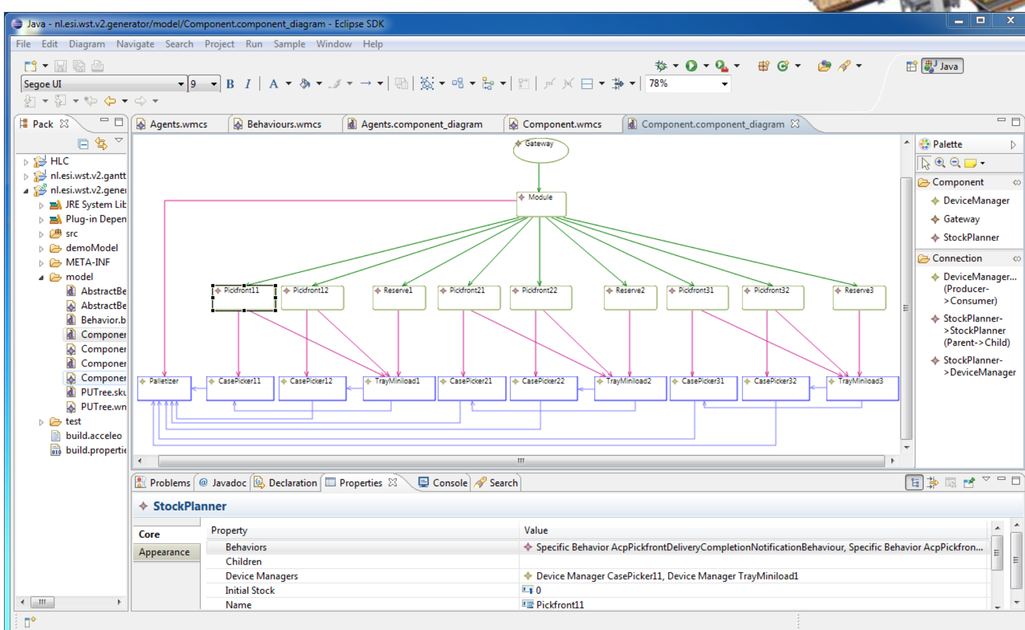
Example 1: Transport simulation

Example 2: Warehouse control simulation





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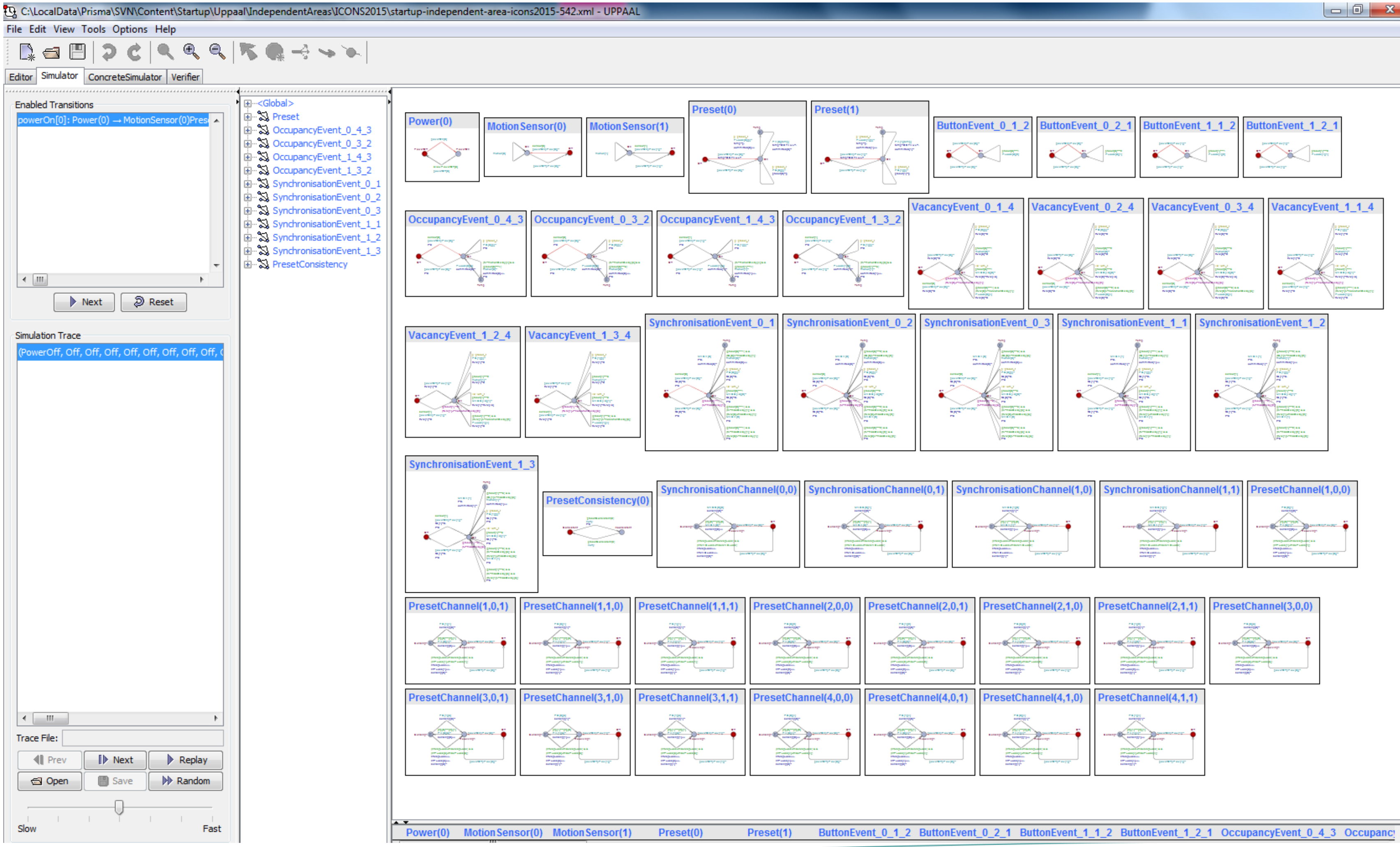
Example 3: Lighting system control model checking



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Testing vs. simulation vs. model checking

Aspect	Testing	Simulation	Model checking
What is executed?	Implementation	Model	Model
When applied?	Right side of V	Left (and right) side of V	Left (and right) side of V
How quickly?	Real time	Simulated time	Simulated time
What is tested?	One scenario (only most likely ones)	One scenario (only most likely ones)	All scenarios (including unlikely ones)
What to validate?	Implementation	Model	Model
How to validate?	Using specification	Using specification or test system	Using specification or test system
How scalable?	Scalable	Scalable	State space explosion challenge