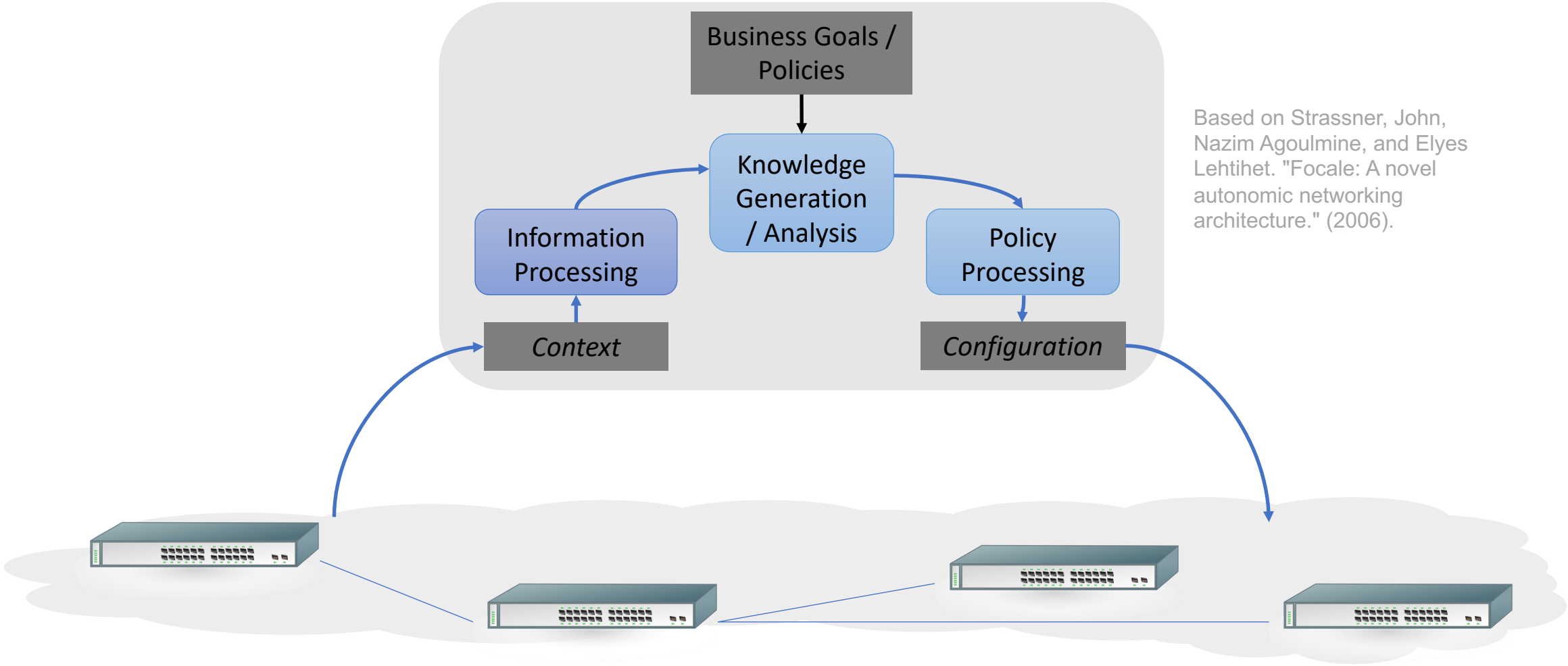
Using the RFC 7575 and Models at Runtime for Enabling Autonomic Networking in SDN

Felipe A. Lopes

Instituto Federal de Alagoas (IFAL)

Autonomic Networking Management



Based on Strassner, John, Nazim Agoulmine, and Elyes Lehtihet. "Focale: A novel autonomic networking architecture." (2006).

Autonomic Networking Management in SDN

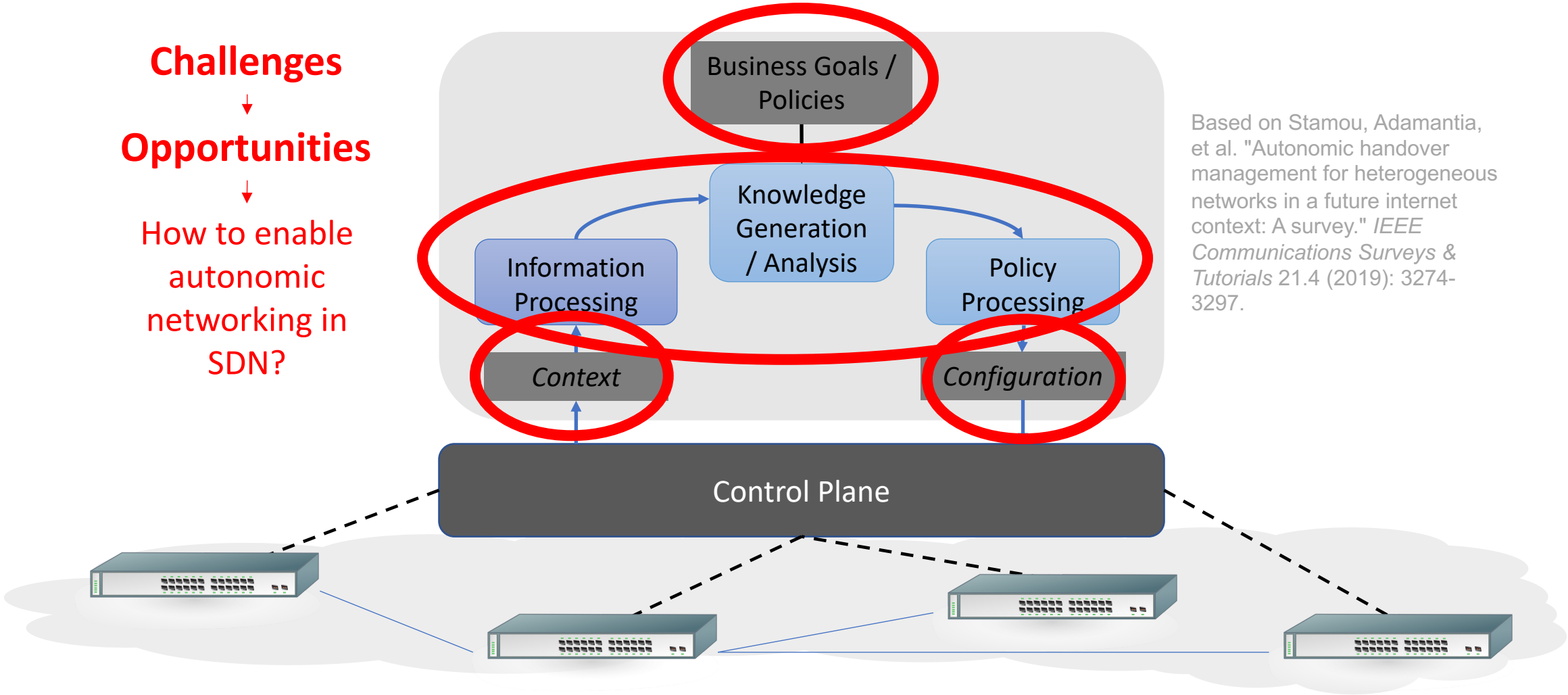
Challenges

↓

Opportunities

↓

How to enable autonomic networking in SDN?

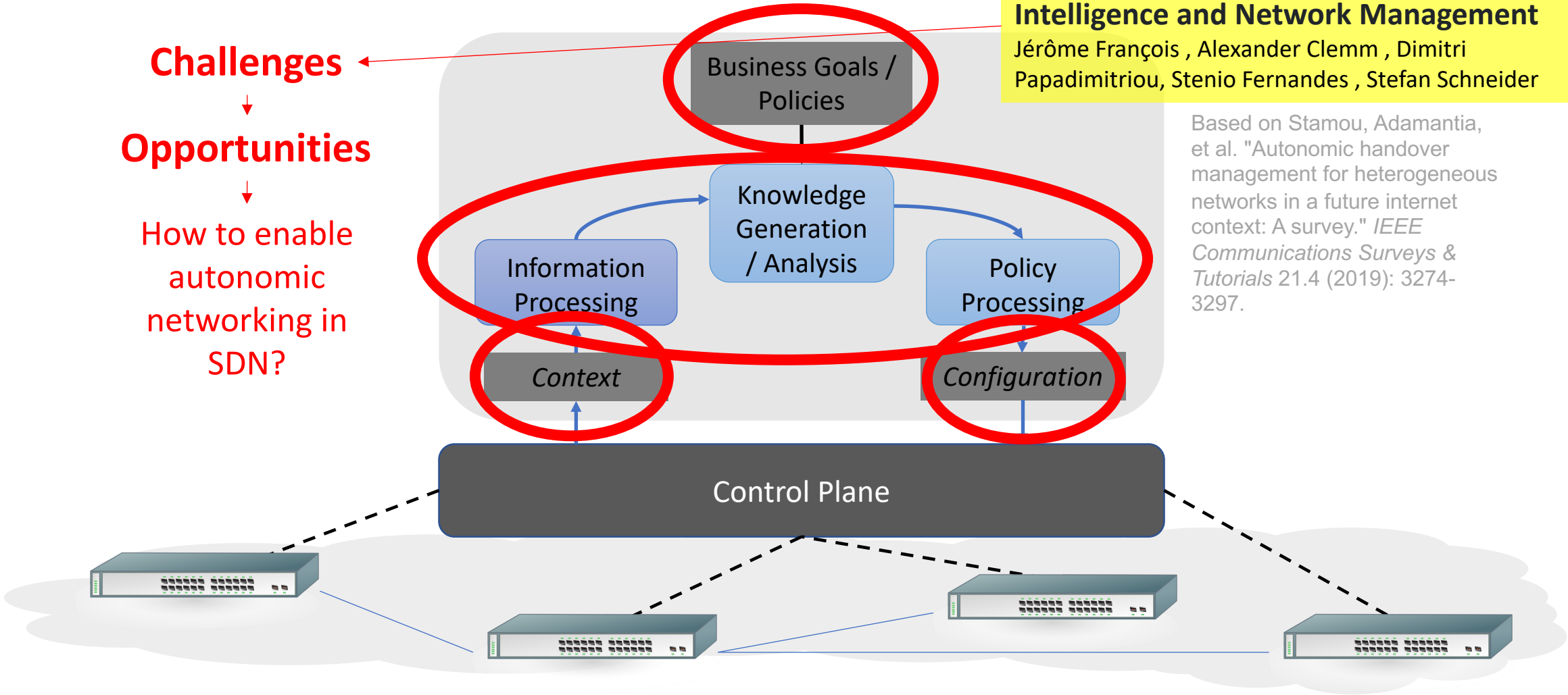


Based on Stamou, Adamantia, et al. "Autonomic handover management for heterogeneous networks in a future internet context: A survey." *IEEE Communications Surveys & Tutorials* 21.4 (2019): 3274-3297.

Autonomic Networking Management in SDN

Research Challenges in Coupling Artificial Intelligence and Network Management
Jérôme François , Alexander Clemm , Dimitri Papadimitriou, Stenio Fernandes , Stefan Schneider

Challenges
↓
Opportunities
↓
How to enable autonomic networking in SDN?



Based on Stamou, Adamantia, et al. "Autonomic handover management for heterogeneous networks in a future internet context: A survey." *IEEE Communications Surveys & Tutorials* 21.4 (2019): 3274-3297.

RFC 7575

IETF's Network Management Group (NMRG)

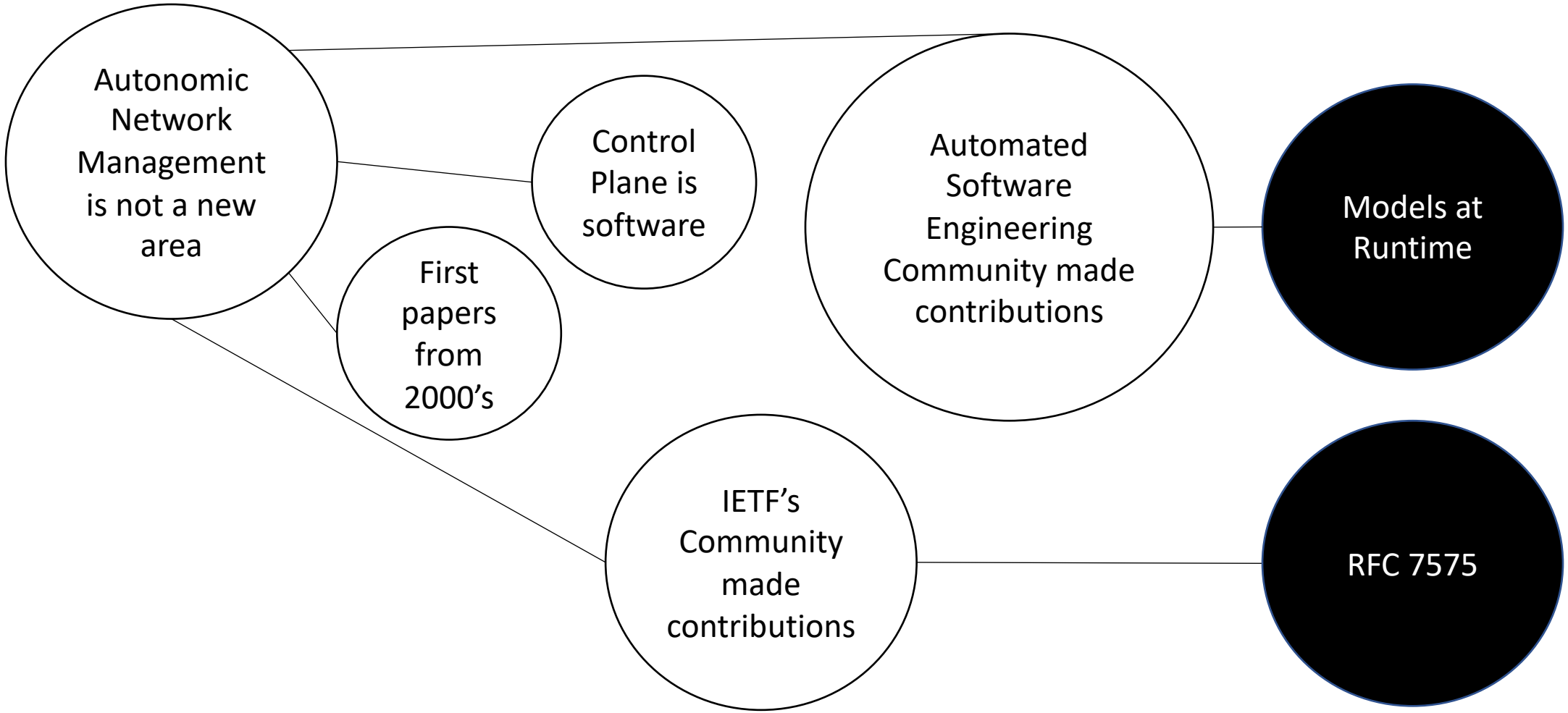
Guidelines and Reference Model for implementing autonomic networks

Objective:
Achieve Self-Management

Scope:

Self-* properties	Design goals
Self-configuration	Coexistence with tradicional management
Self-healing	Decentralization
Self-protection	Distribution
Self-optimizing	Simplification of NBI
	Abstraction
	Autonomic monitoring
	...
	5 more

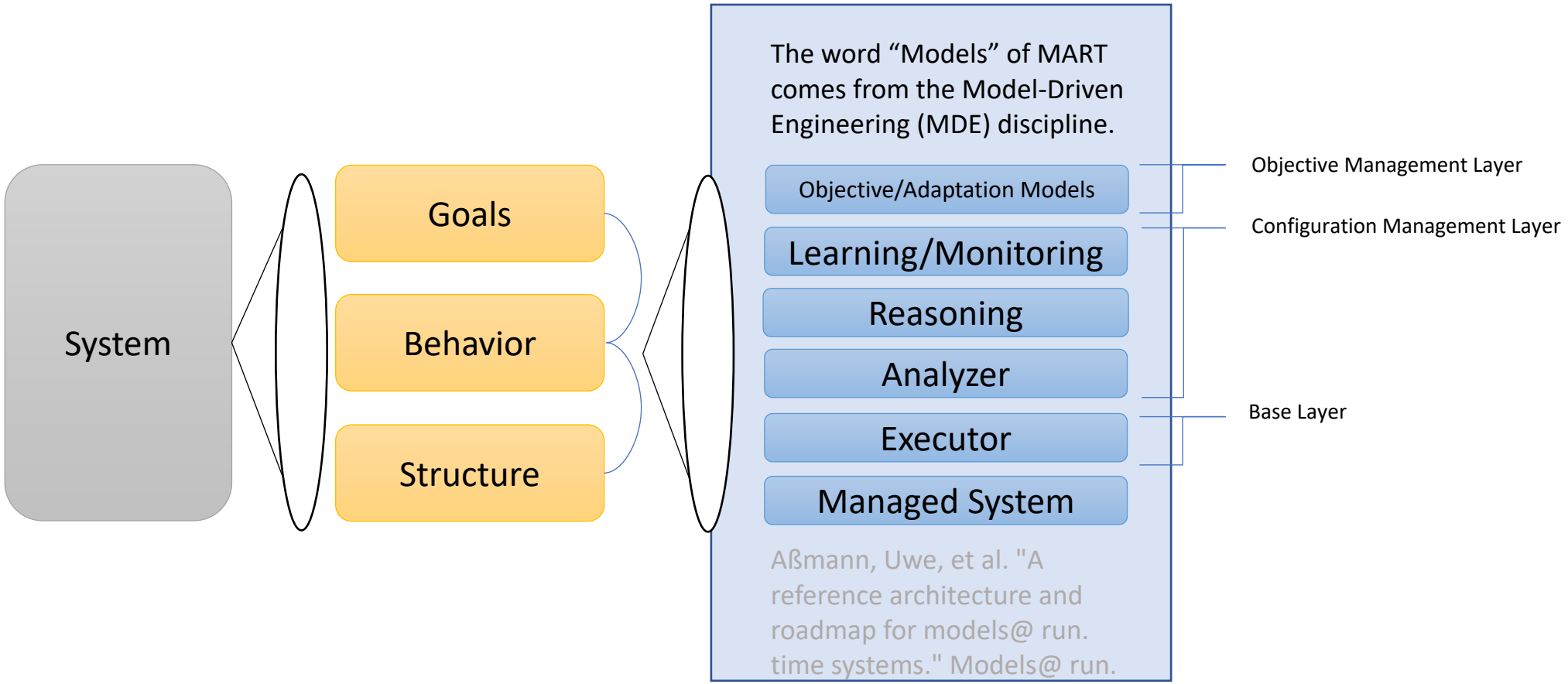
How to enable autonomic networking in SDN?



The use of high-level models and formalisms in other computing areas

- **Software Engineering:** class diagram, UML, sequence diagram, components diagram...
- **Databases:** UML, entity relationship diagram, SQL generators...
- **Machine Learning:** components models and dataflows, neural networks models, black-box/trained models...
- **Networks:** topologies, NETCONF/YANG (is it easy to visualize? how could we define intents? how to grant correctness and the separation of responsibilities?), how to enable zero/one-touch from these models?

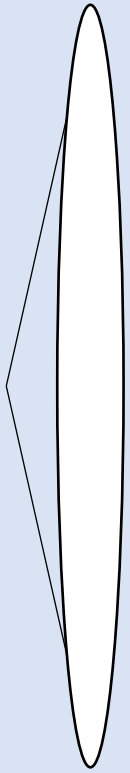
Models at Runtime (MART)

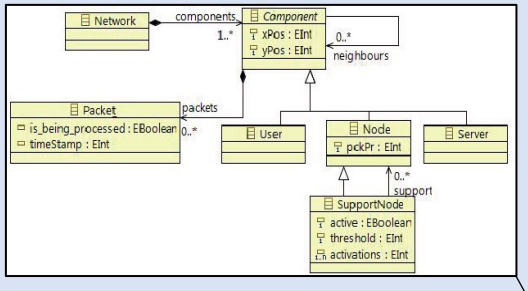


Models at Runtime (MART)

The word “Models” of MART comes from the Model-Driven Engineering (MDE) discipline

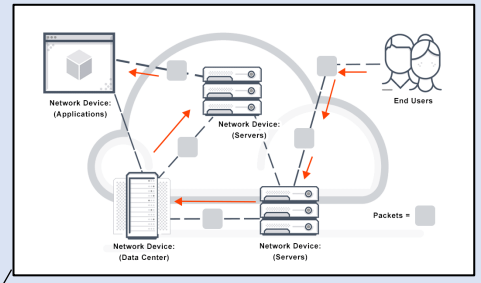
- Objective/Adaptation Models
- Learning/Monitoring
- Reasoning
- Analyzer
- Executor
- Managed System



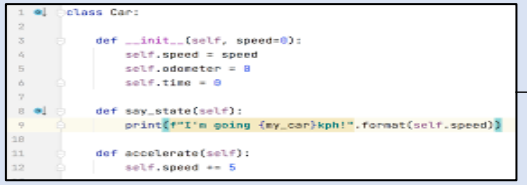


Metamodels

Concrete Syntax



Modeled System

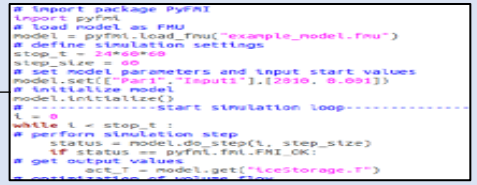


```
class Car:

    def __init__(self, speed=0):
        self.speed = speed
        self.odometer = 8
        self.time = 0

    def say_state(self):
        print(f"I'm going {my_car}kph!".format(self.speed))

    def accelerate(self):
        self.speed += 5
```

Code Templates

Monitoring

Machine Learning Algorithms



```
# import package PyFMI
import pyfmi
# load model as FMU
model = pyfmi.load_fmu("example_model.fmu")
# define simulation settings
stop_t = 24*60*60
step_size = 60
# set model parameters and input start values
model.set(["Par1","Input1"],[2030, 8.001])
# initialize model
model.initialize()
#----------------Start simulation loop----------------
t = 0
while t < stop_t :
# perform simulation step
    status = model.do_step(t, step_size)
    if status == pyfmi.fmi.FMI_OK:
# get output values
        act_T = model.get("iceStorage.T")
# retrieve values from
```

Generated Code

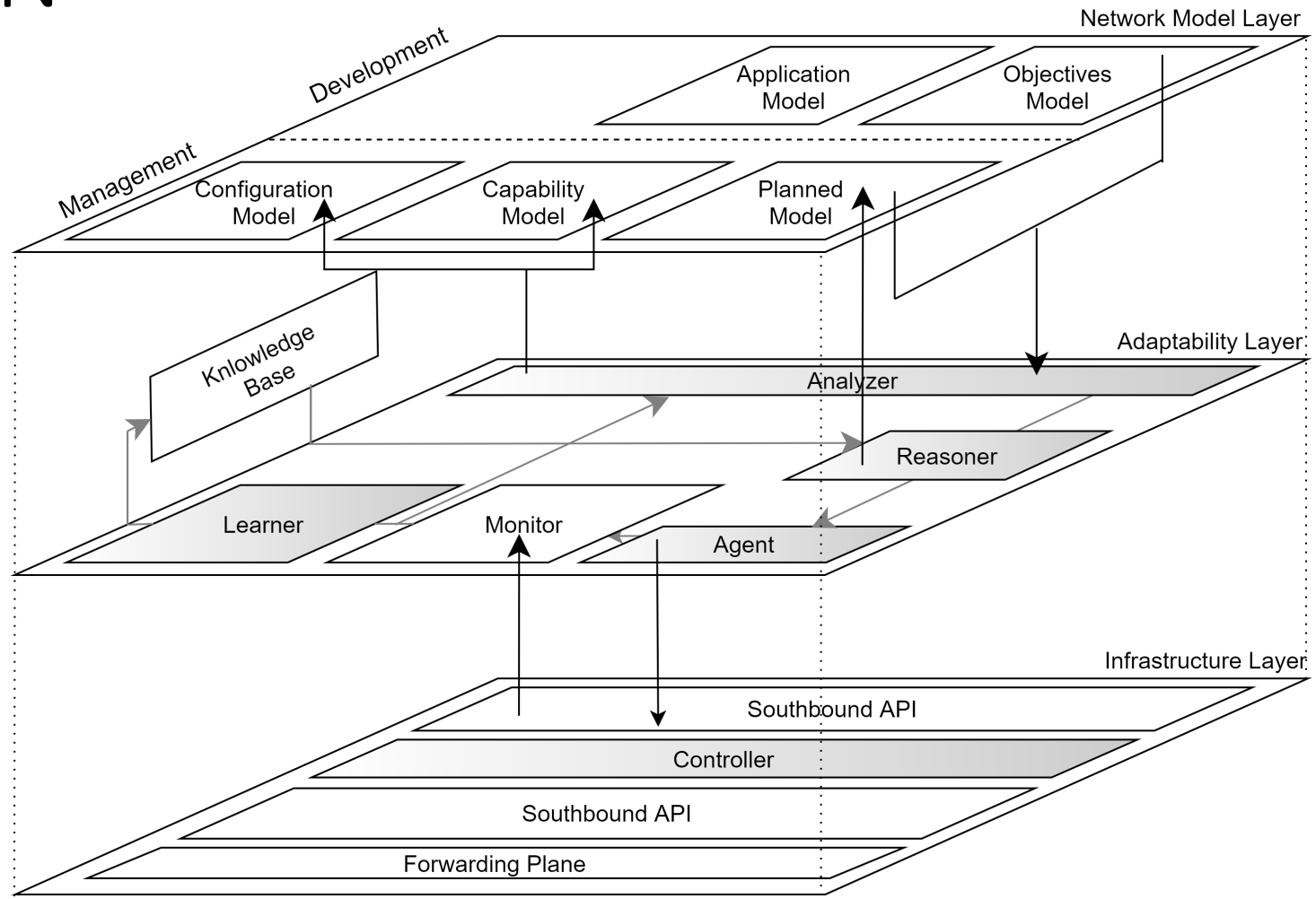
Runtime Models

Aßmann, Uwe, et al. "A reference architecture and roadmap for models@ run. time systems." Models@ run. time. Springer, Cham, 2014. 1-18.

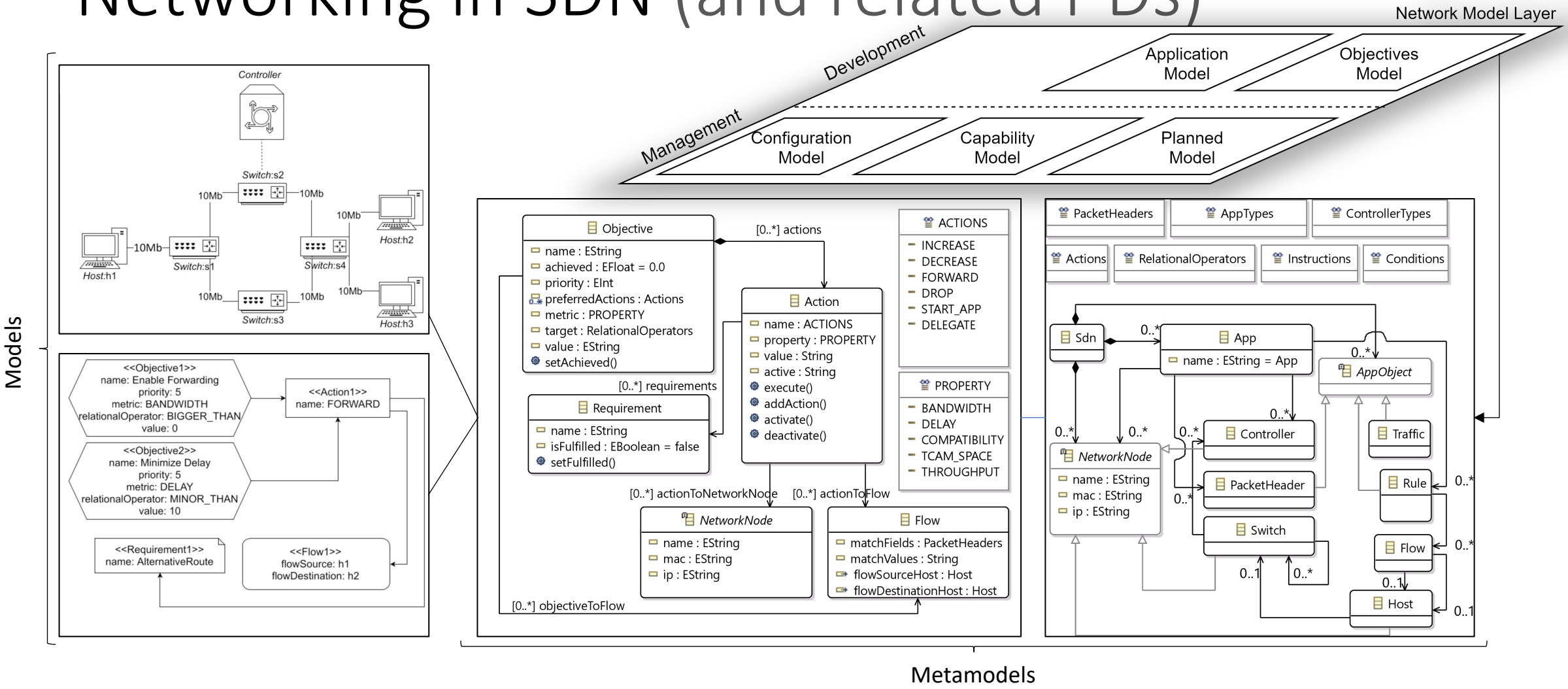
RFC 7575 and MART for Autonomic Networking in SDN

Proposed MART Architecture

RFC 7575 Design Goals
Self-configuration
Self-healing
Self-optimizing
Abstraction
Autonomic Reporting
Independence of Function and Layer
Full Life-Cycle Support



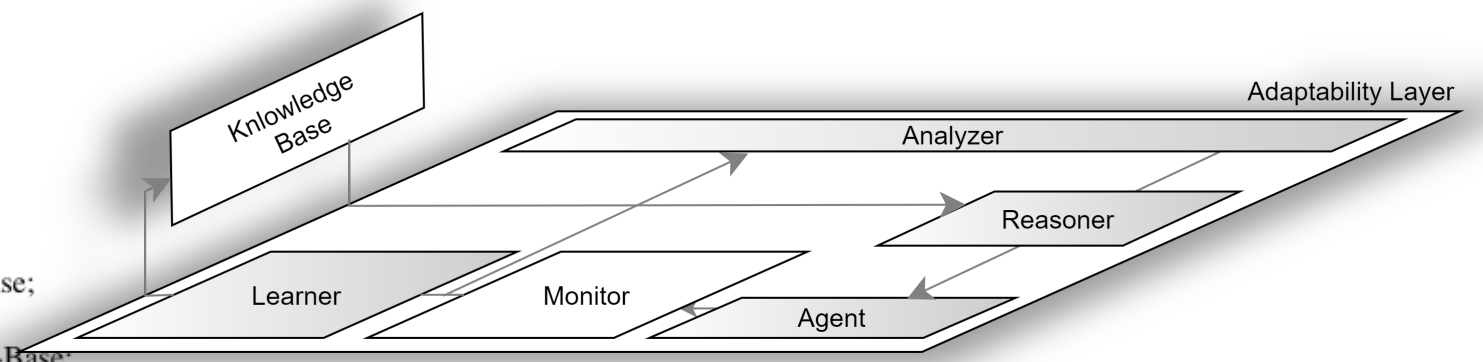
RFC 7575 and MART for Autonomic Networking in SDN (and related I-Ds)



RFC 7575 and MART for Autonomic Networking in SDN

Input: Retrieve data from the K-Base; *if exists*
Input: Initialize weights for action-value pairs, state s_t, objective g;
Data: *reached* = false;
Data: *episode* = 0;
begin
  while *!reached* **do**
    for *step<learning_rate; step++* **do**
      Select action a_t in s_t;
      Query network parameters in s_t;
      Select a parameter $param_t$;
      $\epsilon = \epsilon - (step/learning_rate) * \epsilon$;
      Execute action a_t for $param_t$;
      Observe new state s_{t+1};
      Calculate reward r_t *and* Store experience in K-Base;
      Update $param_t$ in the Planned Model;
      Collect samples of n randomized transitions of K-Base;
      Calculate discount factor d of the reward r_t;
      Update the transition t_t with d;
      Train the *Q-Network* with the new d values of transition t_t, $s_t + 1$, and a_t;
      reached = compare(g, $better_t$, $worst_t$)
    end
    episode++;
  end
end

Development and Management Models as inputs



Running code / Network rules as outputs

Discussion @ NMRG

- The conceptual differences between Intent, Policy, and Service models are clear at the draft:
  - “Intent-Based Networking - Concepts and Definitions” (Alexander Clemm, Laurent Ciavaglia, Lisandro Zambenedetti Granville, Jeff Tantsura)
  - Is the proposed MART approach a feasible way to implement these abstractions?
- Could the Autonomic Resource Control Architecture (ARCA) (from the draft entitled “Artificial Intelligence Framework for Network Management”) benefit from a new abstraction layer?
- How intents will be “translated” into network rules? And how they will be integrated with the monitoring and adaption actions?
  - A MART-based definition may help

Conclusions

Proposal for enabling autonomic network management in SDN

Knowledge combination

High-level modeling for implementing autonomic behavior

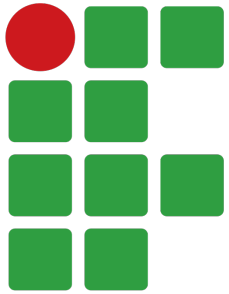
Some design goals could not be covered

Discussion

Proper functioning and suitable performance

Acknowledgement

FUTUREWEI
Technologies



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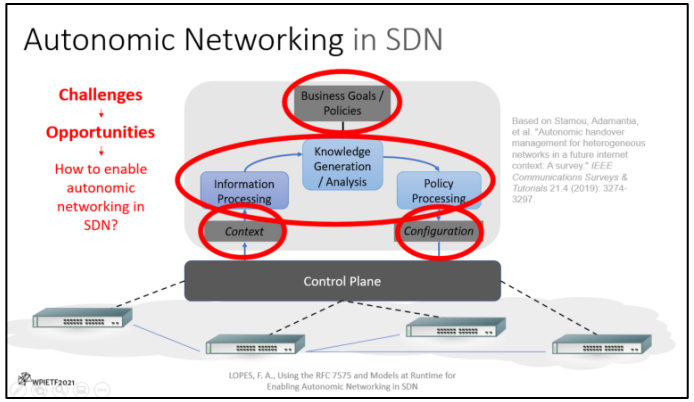
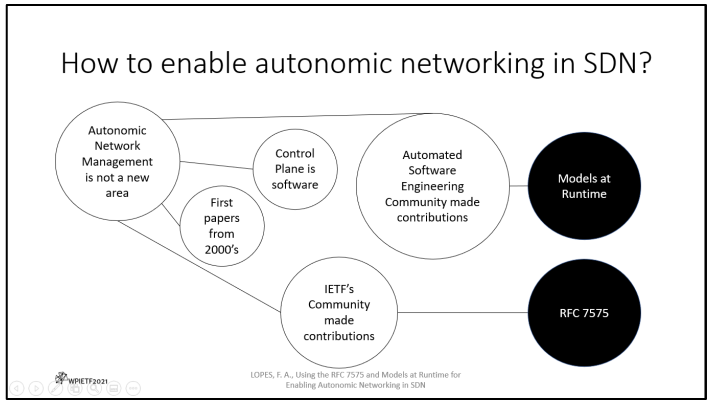
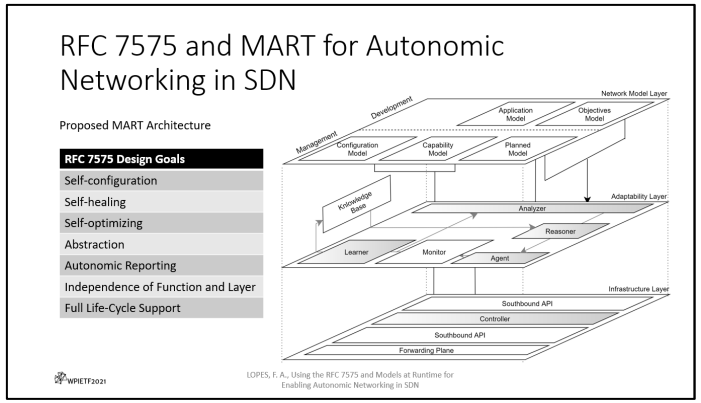
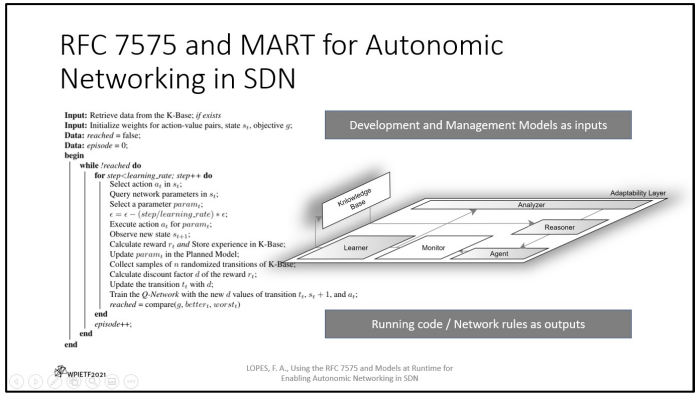
and Analysis

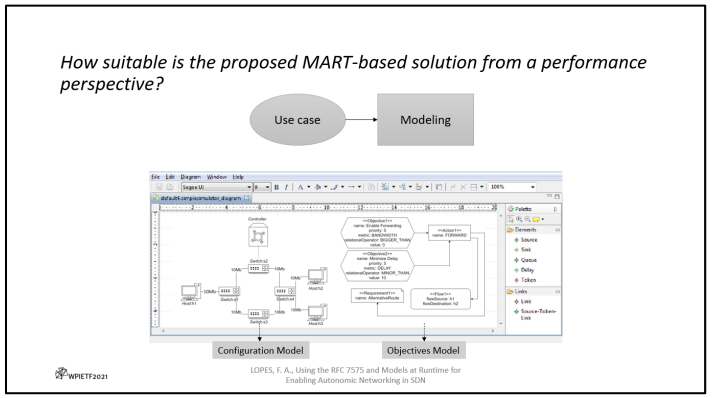
Thank you! Questions? <felipe.alencar@ifal.edu.br>











Backup slides

Evaluation

Which RFC 7575's design goals the proposed MART-based solution could not achieve? Why?

How suitable is the proposed MART-based solution from a performance perspective?

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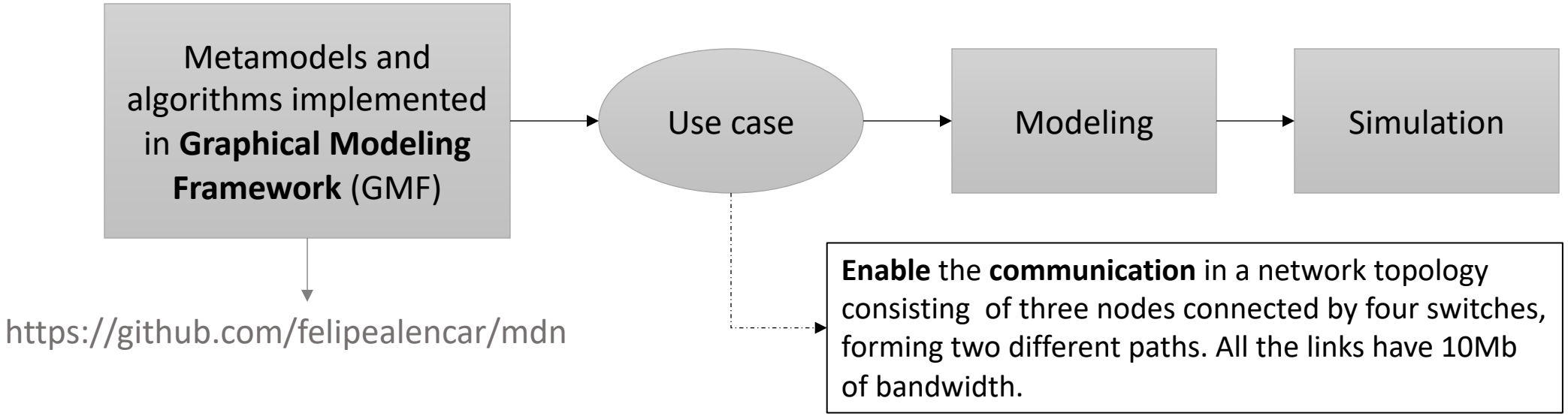
Evaluation

Which RFC 7575's design goals the proposed MART-based solution could not achieve? Why?

RFC 7575 Design Goals not achieved	Reason
Self-protection	Currently, metamodels do not have entities for representing such goal.
Coexistence with Traditional Management	The final ANM system supports only intents.
Secure by Default	The final ANM system cannot assert the membership of all components as required by the RFC.
Common Autonomic Networking Infrastructure	Achieving this goal using a unique MART solution would increase the complexity of metamodels.

Evaluation

How suitable is the proposed MART-based solution from a performance perspective?



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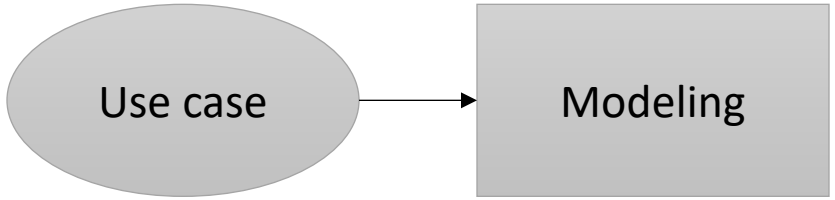

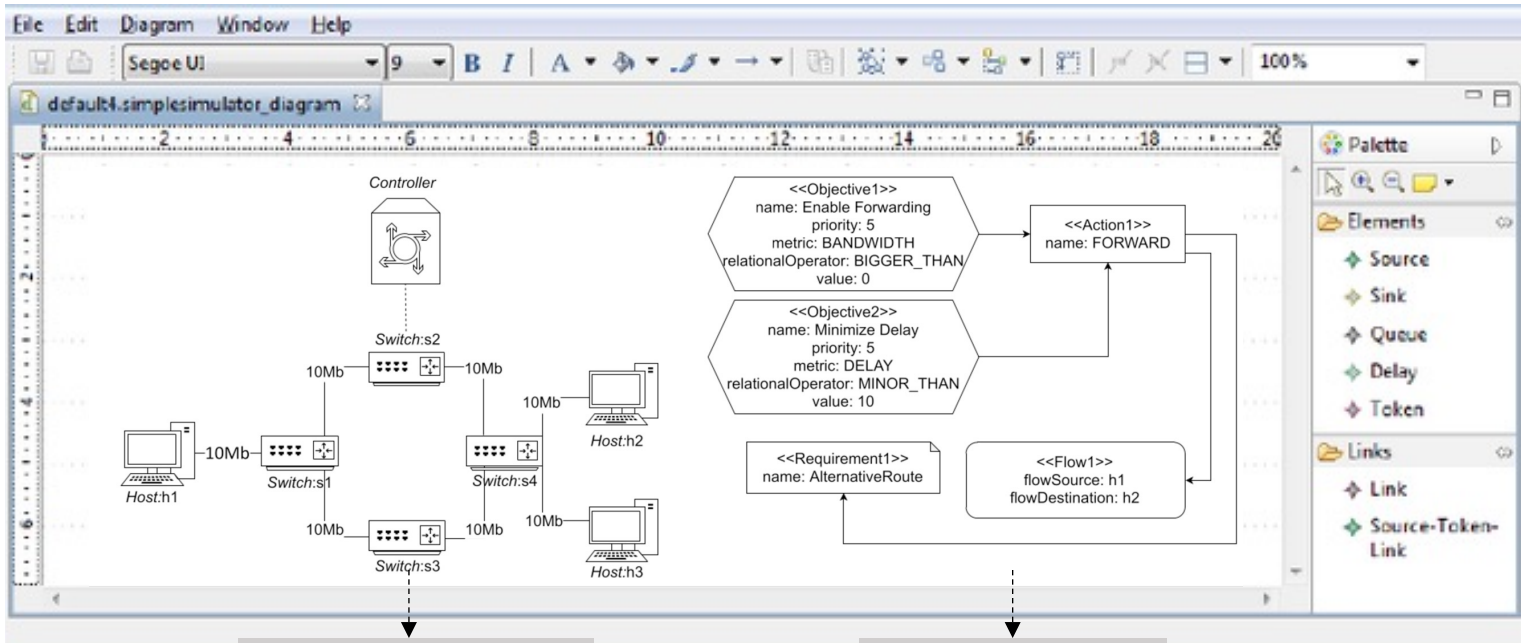

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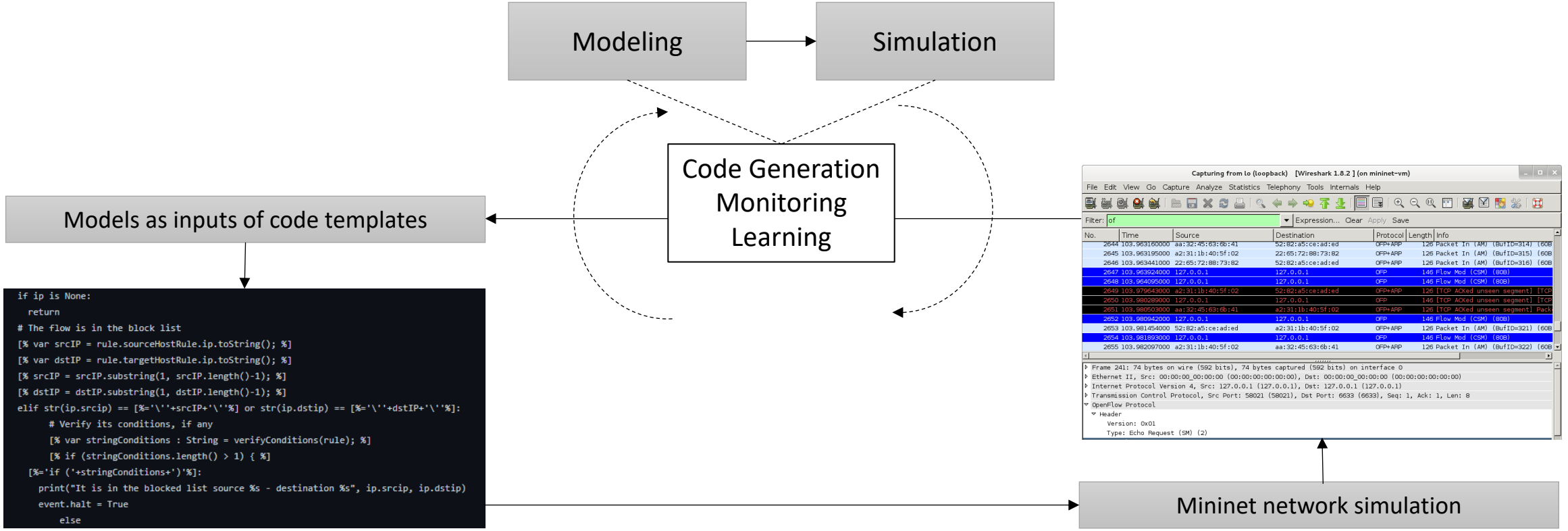
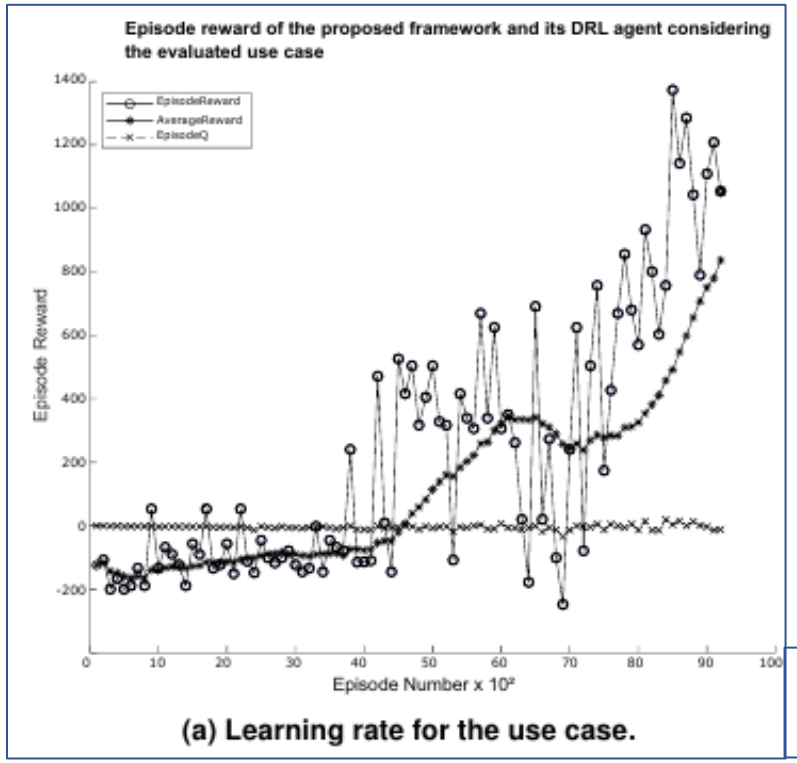


How suitable is the proposed MART-based solution from a performance perspective?

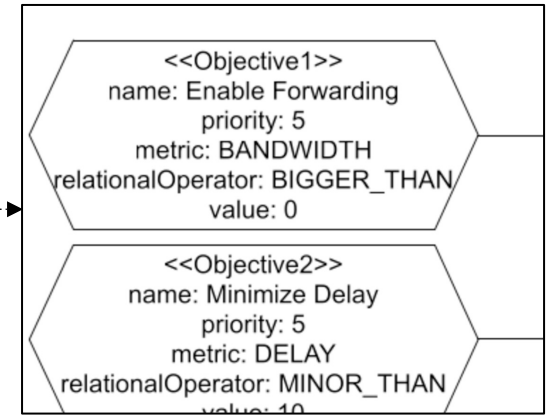
Modeling → Simulation



(a) Learning rate for the use case.

Learning rate: 0.0001
Activation function: ReLu

Select actions and network monitoring to check if h1 reaches h2.



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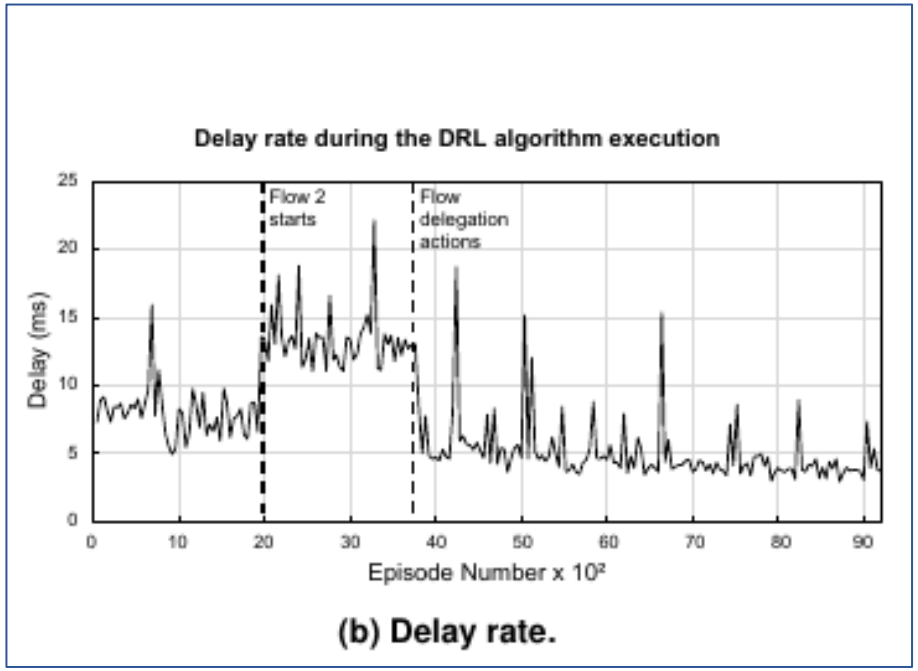
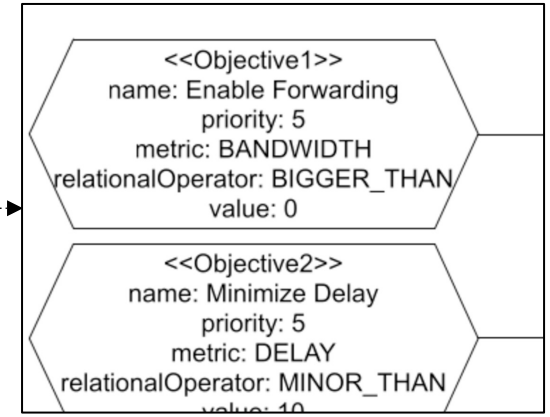
Introduce congestion traffic to verify model transformations and reasoning in the action selection process