Towards Continuous Evolution through Automatic Detection and Correction of Service Incompatibilities

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An initiative of industry, academia and TNO

Motivation

Thales systems have life time > 30 years and require upgrades

- Requirements **significantly change** during life time
- New software with **new capabilities** becomes available

System upgrades can take 1-2 years and happen every 10-15 years

- Many small updates collected into **big infrequent upgrades**
- System **evolves slowly** and in big steps, increasing risk

Continuously evolution reduces risk and increases added value

Continuous Evolution

Facilitated by service-oriented architectures

Service-oriented architectures provide flexibility

- Components provide and require services for particular functionality
- Service dependencies are **dynamically resolved**
- **Abstracting component** implementing service through **service interface**
- **Decouples application** from a particular technology and implementation

Service-oriented Architecture

Thales INAETICS platform provides the context of this work

- Service-oriented architecture providing resilience and evolvability

Simplified terminology

- Services are implemented by **components** that communicate via message passing
- **Service interface** comprises set of valid **message types** (formal) and **protocol** (informal)
- Messages can be passed either **synchronously** or **asynchronously**

Problem Statement

Updating service interfaces comes with associated challenges

- **Many components** in many products may request or provide services
- Dynamic resolution of service dependencies makes it **less explicit** which components interact
- **Determining impact of update** on components is challenging
- Addressing this problem manually is **expensive** and **time consuming**

This applied research considers the problem of automatically detecting and correcting incompatibilities resulting from service updates

Compatibility

Two types of compatibility are considered:

- **Structural compatibility:**
  messages specified in the service interface, and their fields, match those used by the client in terms of name, type, and semantics.

- **Behavioral compatibility:**
  service and the clients agree on the protocol.

Contributions

Paper presents initial work towards by addressing the stated problem

The paper has three contributions:

1. **Survey of state-of-the-art** in areas of interface specification, and detection and correction of incompatible services
2. **Initial steps towards a methodology** to manage service incompatibilities
3. Work is discussed in context of **simplified case study** of a service in the radar domain

Presentation Outline

Introduction

State-of-the-Art

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Conclusions

Overview of State-of-the-Art

We survey the state-of-the-art in two areas, covering 30 publications:

1. **Interface specification**
   - **Structural specification**, e.g. programming languages and many interface definition languages
   - **Behavioral specification**, e.g. communication state machines, open nets, and process algebras
   - **Combinations of both**, e.g. Dezyne and ComMA languages

2. **Detection and correction of incompatibilities**
   - **Detection** of structural and behavioral incompatibilities
   - **Correction** of (structural and) behavioral incompatibilities through **adapter generation**

Please refer to paper for survey

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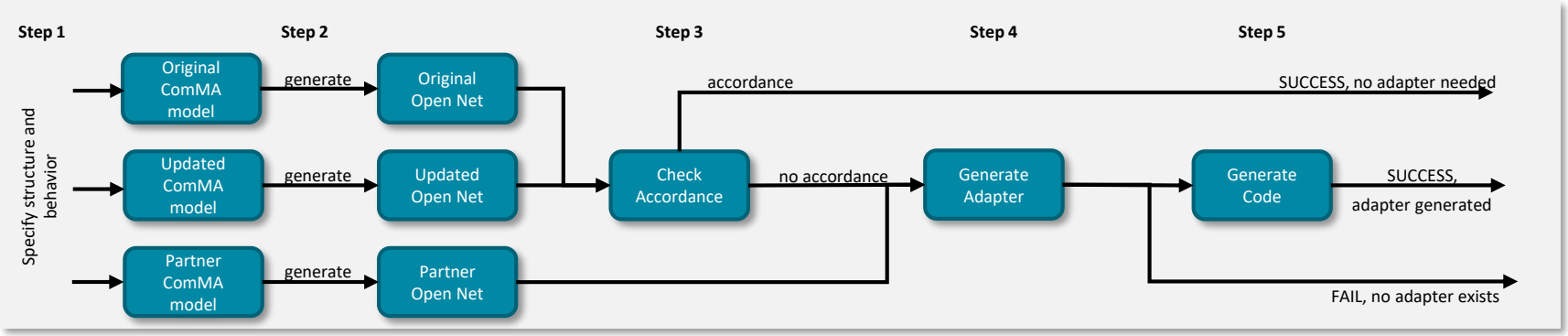
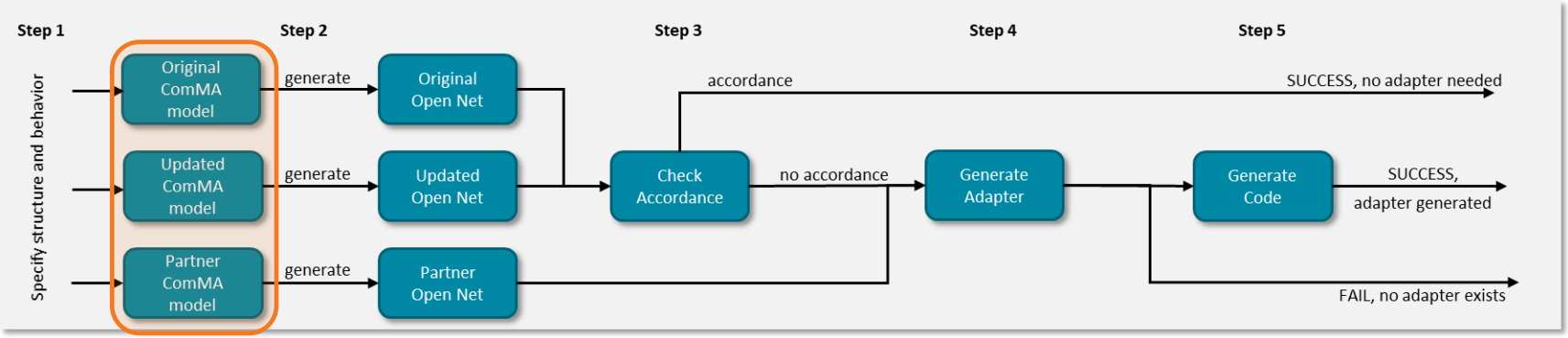
Directions for Methodology

Five-step Methodology

1. **Service Interface Specification** for all services using **ComMA** (design time)
2. **Generate Formal Model** based on **Open Nets** from all specifications (design time)
3. **Check Accordance** between original and update using **operating guidelines**
4. **Generate Adapter** between services using **controller synthesis**
5. **Generate Code** from adapter model and **deploy** in **INAETICS**



Interface Specification



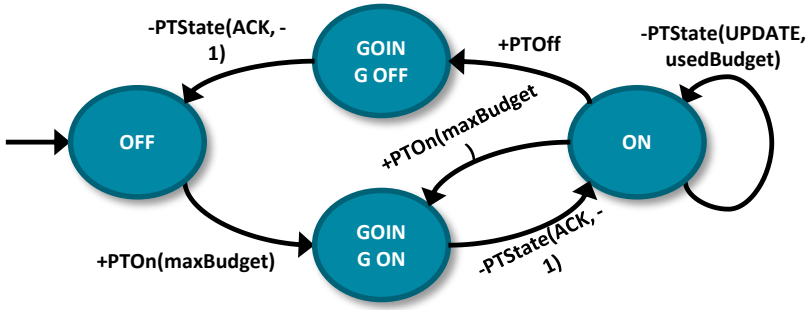
Service Interface Specification

ComMA selected as specification language for five reasons

1. specifies **both structure and behavior**, required to validate both aspects of compatibility
2. models **both synchronous and asynchronous** communication
3. successfully **applied in industry** before, i.e. at Philips
4. **automatic inference** and **migration** of interface specifications simplifies industrial adoption
5. the tooling is based on **Eclipse**, which is one of the most commonly used modeling tools in the embedded domain

Example Service Interface in ComMA

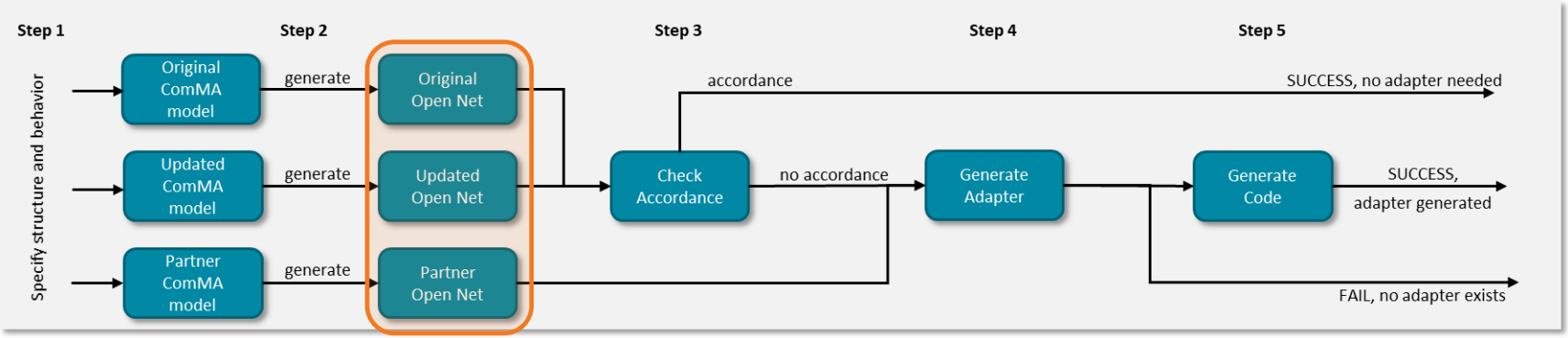
```
Types:

enum Response {
   ACK, UPDATE
}

record PTResponse {
   Response response
   real usedBudget
}

Signature:

signals
   PTOn(real budget)
   PTOff

notifications
   PTState(PTResponse
response)
```




```
Interface:

variables
   PTResponse ptResponse

machine StateMachine {
   initial state OFF {
      transition trigger: PTOn(real budget)
         do:
            ptResponse.response :=
Response::ACK
            ptResponse.usedBudget := -1.0
            PTState(ptResponse)
         next state: ON
   }

   state ON {
      transition trigger: PTOff
         do:
            ptResponse.response :=
Response::ACK
            ptResponse.usedBudget := -1.0
            PTState(ptResponse)
         next state: OFF

      // Periodic update
      transition do:
         ptResponse.response :=
Response::UPDATE
         PTState(ptResponse)
      next state: ON
   }
}
```

Case study changes this service by replacing some uses of a state message with a new Performance message

Generate Formal Model



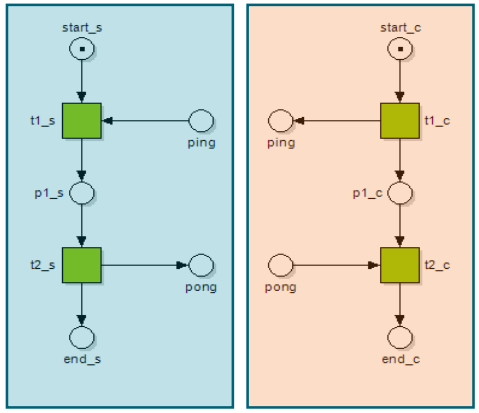
Generate Formal Service Model

Open Nets chosen as formal service model

- Special type of Petri Nets with unconnected interface places

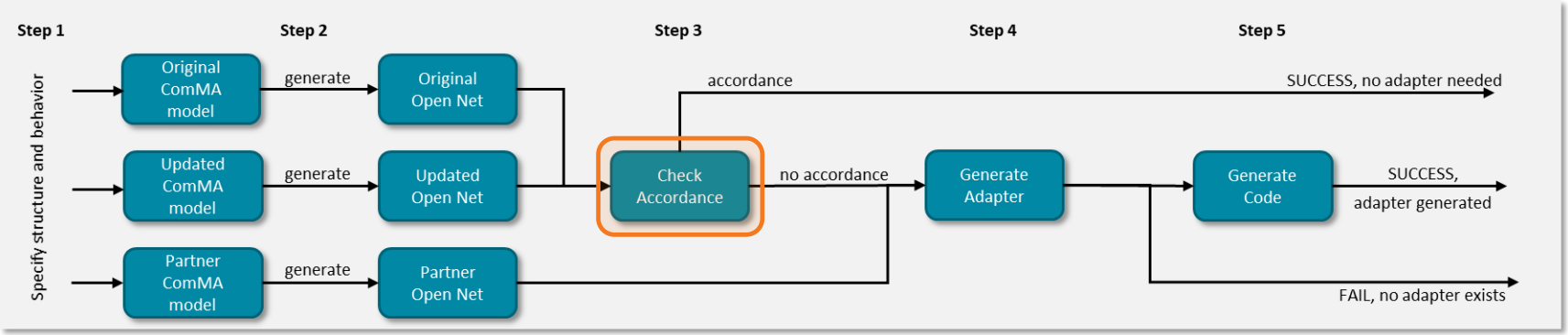
Open Nets for three main reasons:

1. possible to **transform** a ComMA specification into an Open Net
2. support **both synchronous and asynchronous communication**
3. **existing analysis methods** are available, supported by **academic tools**



Server Client

Check Accordance between Original and Updated Nets



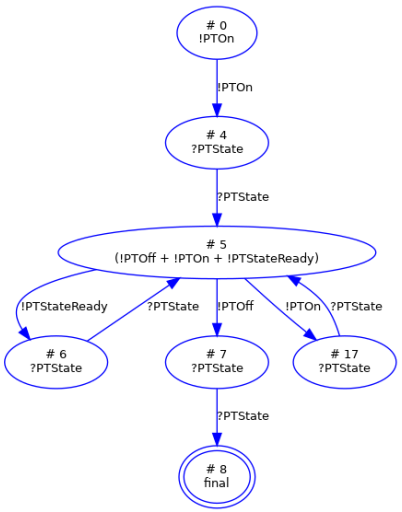
Check Accordance

Method based on Operating Guidelines chosen

- Operating Guidelines are a **characterization of all possible partners**
- Basic idea is to check if all partners supported by one service are also supported by another
- **Context-independent method** covers all possible partner services simultaneously, advantage if the number of partners is large or unknown
- Method is **exact** and supported by **academic tool Fiona**

Accordance Checking Modified PeriodicTask

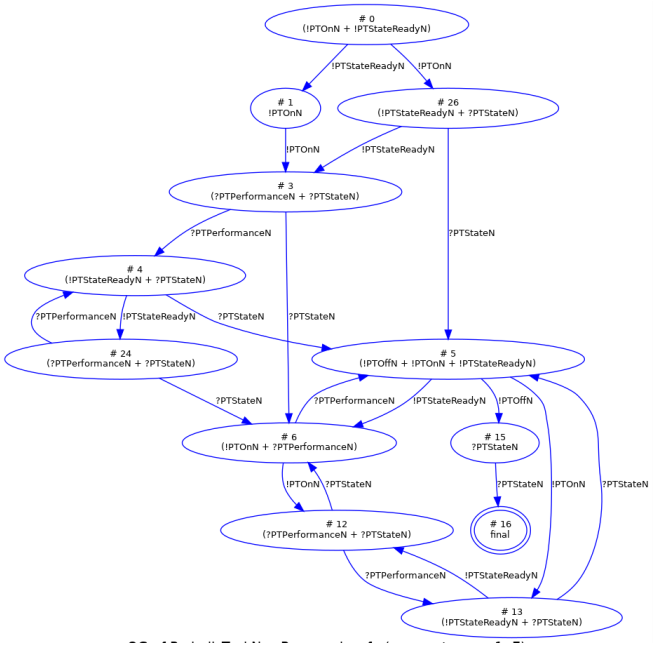
v1



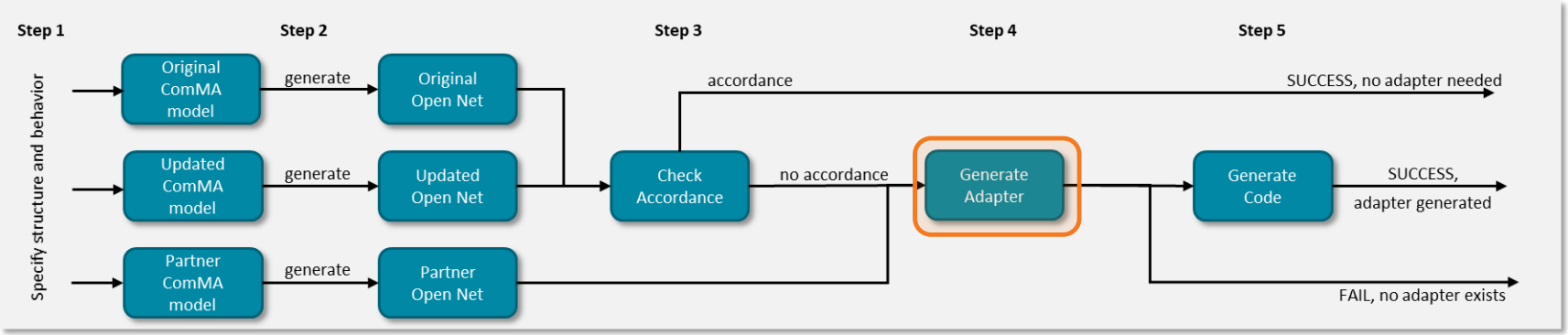
v2 does not simulate v1, nor are they equivalent

Adapter needed!

v2



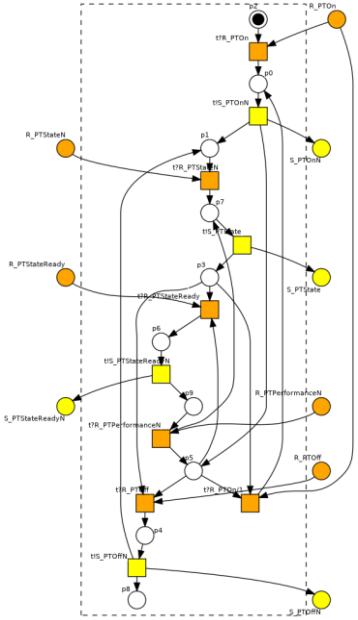
Generate Adapter



Generate Adapter

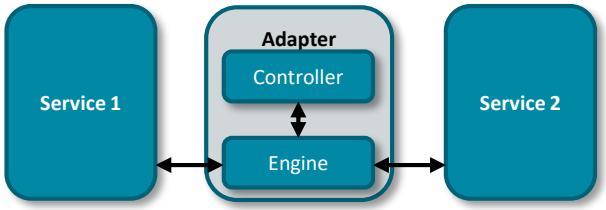
Adapter generation approach based on controller synthesis

- Adapter architecture comprises **Engine** and **Controller**
- Engine focuses on **data flow and transformations**
- Controller determines **order of transformation and sending**
- Engine structure follows directly from mapping rules
- **Controllers are synthesized** to guarantee deadlock freedom
- Approach supported by **academic tools Marlene and Fiona**

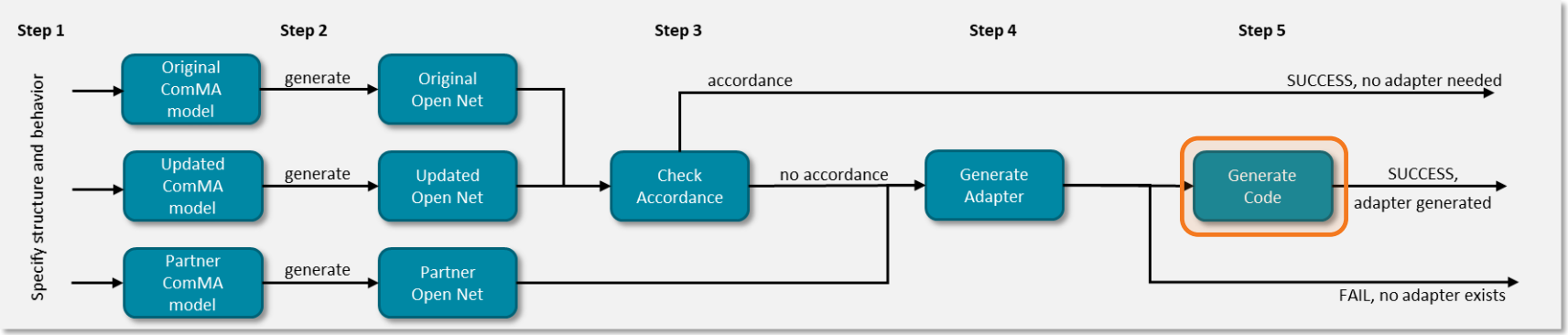


Mapping Rules

```
PTOn -> PTOn;
PTOff -> PTOff;
PTStateReady -> PTStateReady;
PTState -> PTState;
PTPerformance -> PTState;
```



Generate Code



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Problem

- Systems with **long life time** need to **continuously evolve**
- **Service-oriented architectures** are enablers of continuous evolution
- Managing **compatibility of evolving services** remains a challenge

Methodology for detection/correction of incompatibilities was presented

- **Technology selection** based on **survey of state-of-the-art**
- **Specifying structure and behavior** of service interface using **ComMA**
- **Generate Open Nets** to **check accordance** of update and **synthesize adapters**, if necessary

I am happy to tell you more and demonstrate our work!