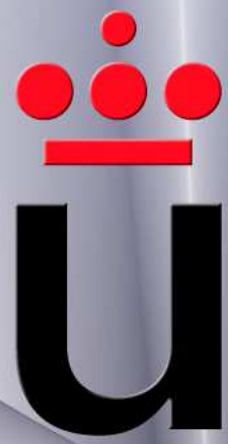
Collaborative Context Features for Critical Systems



Universidad Rey Juan Carlos

Rafael Capilla , Rey Juan Carlos University, Spain
Mike Hinchey, Lero research center, Ireland
Francisco J. Díaz, Ineco, Spain

9th International Workshop on Variability Modelling of Software-intensive Systems, Hildesheim, Germany, January 21-23, 2015

Overview

- Context in Software Development
- Challenges in Context-aware Critical Systems
- From FM to Context Variability Modeling
- The CC Feature Model Approach
- AMS Case Study
- Research agenda

Context in Software Development

• Context is becoming more and more important for many type of systems

• Systems using context information: Mobile, Ubiquitous, Robots, WSN, Critical SoS in various application domains, Automotive, Smart Cities, etc….

• Context is understood as the *circumstances that form the setting for an event*

Context in Software Development

- Little research on what type of context is needed for a developer to understand and complete a task
- How can we model context around a task?
- How can we use context-based models in software development at large?
- How to model and manage different types of context information

Challenges in Context-aware critical Systems

- Different type of systems manage context information differently
  - Systems that only sense and react (Smart Home Systems)
  - Systems that need a smart response (Smart Cities, Windmill Farms)
  - Systems demanding adaptive reaction (Robots, Intelligent vehicle systems)
  - Critical systems composed by different context data (Airport Management Systems, Power Plants)

Challenges in Context-aware critical Systems

- *Context properties are used for autonomous decision-making*
- *Dynamic Variability for making runtime and optimal decisions*
- *Manage "unpredictable" scenarios (new context features)*
- *Highly evolvable systems that demand adding and removing features at runtime (open variability models)*

6

Challenges in Context-aware critical Systems

- Systems demand more and more dynamic capabilities

- Different types of systems with strong runtime needs use *Context data* used to change their configuration or state at runtime

- Beyond the simple feature activation/deactivation there is a need to add/remove/change features dynamically

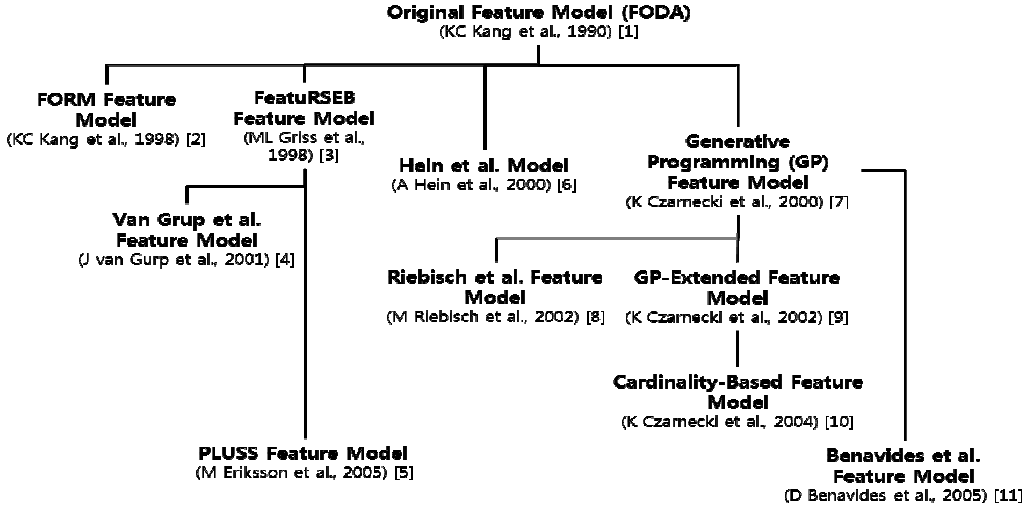
Mobile software offer users highly configurable devices and system's options in the customer side at post-deployment time

A Robot might need to replace dynamically the feature supporting a differemt navigation plan without stopping the robot to perform such update

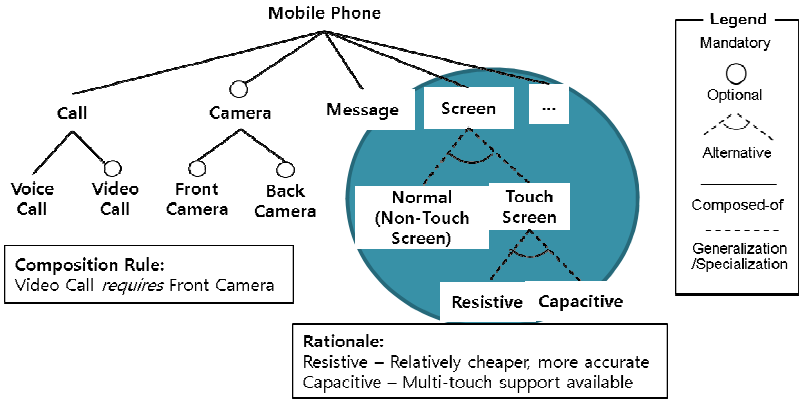
From FM to Context Variability Modeling

- Feature-oriented domain analysis (FODA) is the technique being used for modeling the C&V aspects of systems

- Different FODA models and their extensions have been proposed since the 90's (*Variability Modeling, In: Systems and Software Variability Management, Kang et al, 2013*)



From FM to Context Variability Modeling



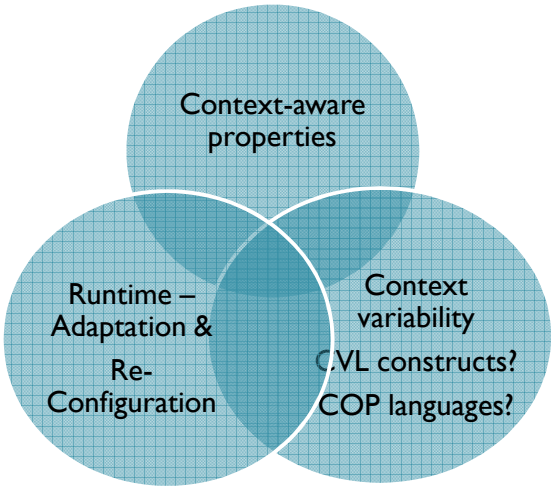
Feature models poorly describe context information and don't represent the collaborative aspects except for basic dependencies between features

Variability

"*The ability of a system to be efficiently extended, changed, customized, or configured for use in a particular context*"
Svahnberg, Gurp, Bosch (2005)

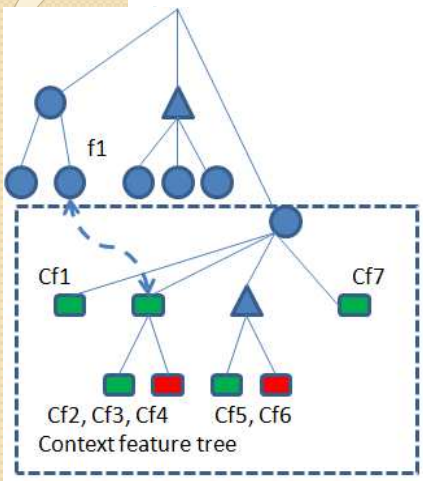
From FM to Context Variability Modeling

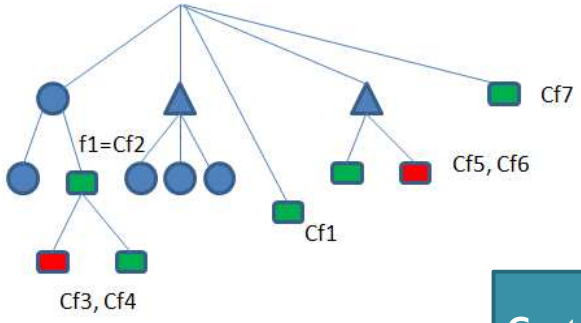
•Context properties of systems using context-aware information can be modeled using the notion of "Context Variability"→ Extend classical Domain Analysis (Context Analysis)



From FM to Context Variability Modeling

Two different modeling strategies





Context features entrangled in the FODA tree with non-context features

Context features annotated in the Feature Model

Legend

- Feature o variant
- Variation point
- Context feature
- Context feature activated
- Context feature deactivated

Taxonomy of context features

Type 1: Cf1, Cf2
Type 2: Cf3, Cf4, Cf5
Type 3: Cf6, Cf7
Compatiple types: Type 1, Type 3

The CC Feature Model

Collaborative needs and challenges…

- Critical systems need to exchange information
- Context features are suitable candidates to incorporate collaborative capabilities
- Collaborative features support awareness
- Adequate to handle coordinated missions (Swarm projects)

The CC Feature Model

We define types of messages between Context and Collaborative (CC) features using a set of predefined primitives

• Awareness of other collabarative features: Know about the Existence of other features.
PRIMITIVES: Notify, Ping, Awake, etc.

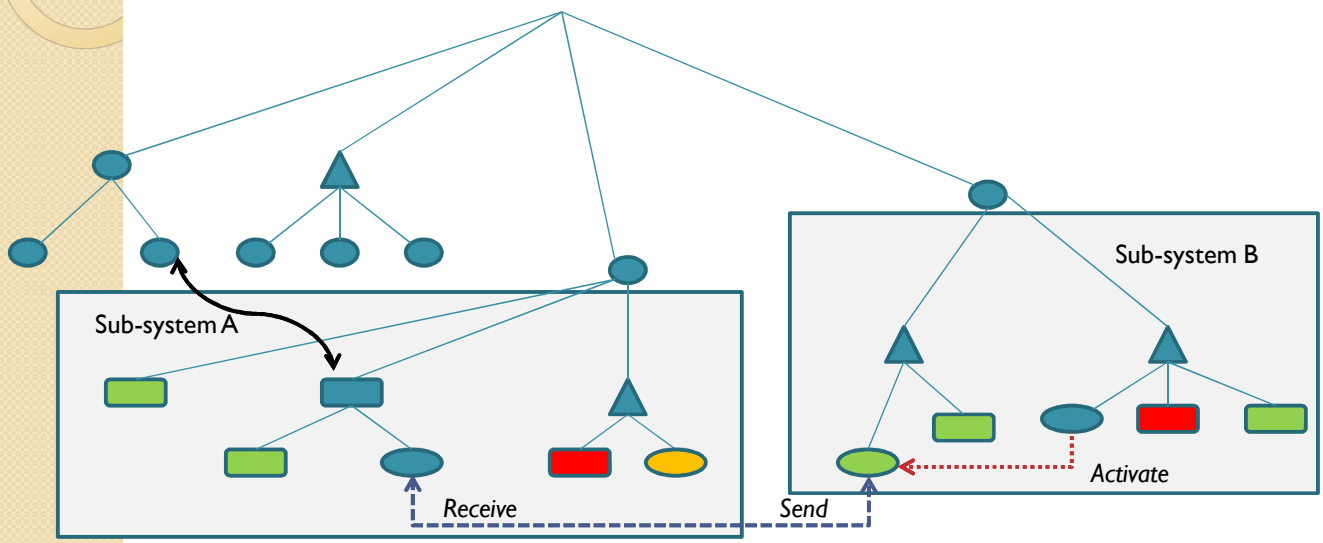
• Send/Receive data: Exchange information between features.
PRIMITIVES: Send, Receive

• Activate/Deactivate: Change the status of context features
PRIMITIVES: Activate, Deactivate

……

The CC Feature Model

We annotate the FM model indicating those context and non-context features and which of them pose collaborative capabilities



AMS Case Study

- A complex System-of-Systems for RT airport operations
- It uses a variety of context-data gathered from a plethora of sensors, cameras, and other devices
- Stringent security requirements and regulations
- AMS Sub-systems must cooperate closely with a high level of integration (AMS Middleware) with third-party systems
- We studied the case of Weather Information System (WIS) and Airfield Lighting System (ALS)

AMS Case Study

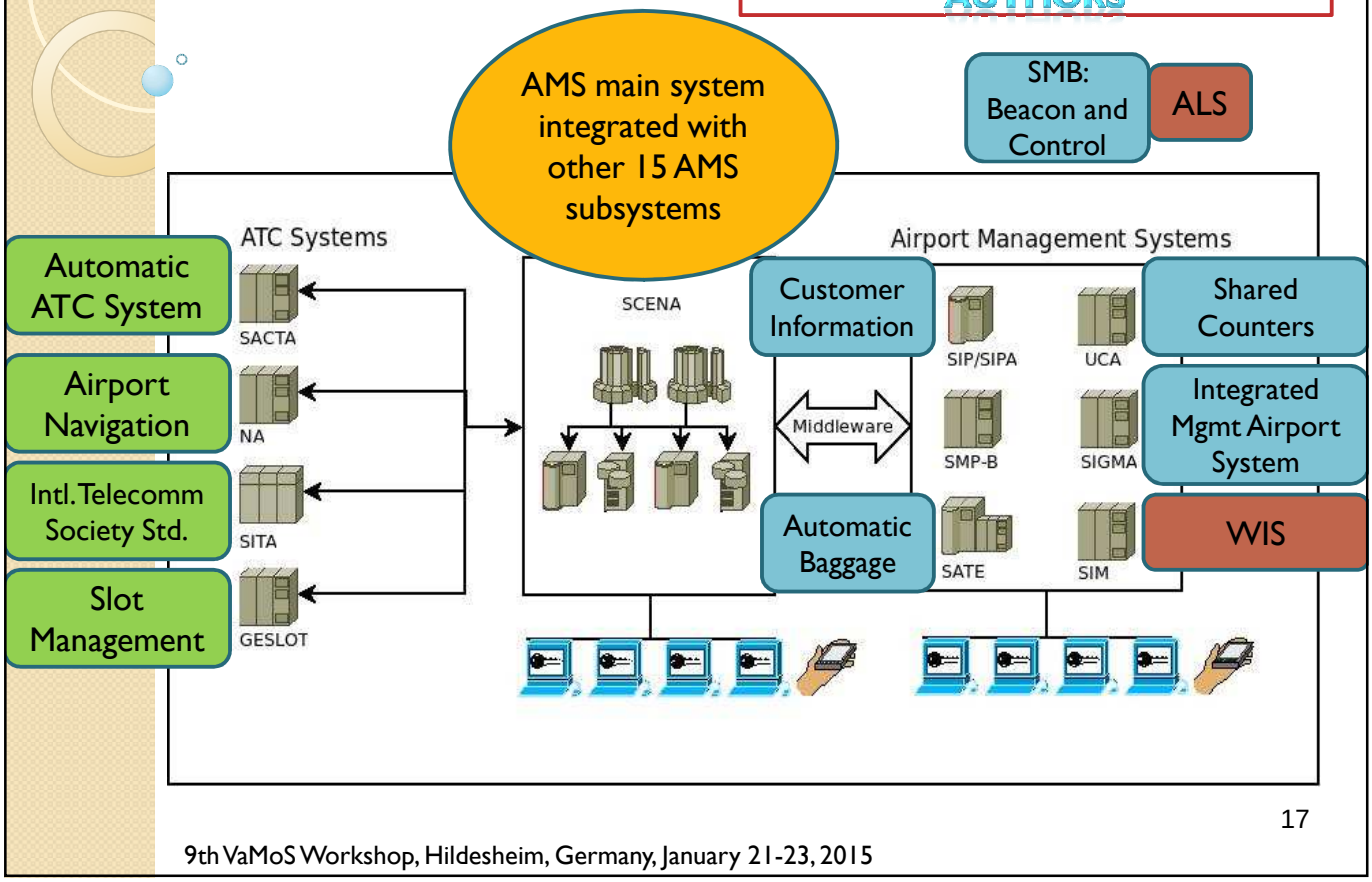
AMS maintenance challenges at Ineco corporation

• Enhance syncronization of elements and subsystems and reduce human intervention by guaranteeing RT operations

• Frequent changes or updates in critical subsystems (e.g., the category of the airport changes)→ Agile post-deployment procedures

• Increasingly runtime demands→Need to add functionality dynamically (new features) and more automatically

AMS Case Study



AMS Case Study

Collaborative tasks in WIS and ALS AMS Sub-systems

Runway Visual Range Sensor

RVR

Wind sensors

Wind

Airfield lighting actions

Temperature and humidity sensor

Temp

Weather Information System

Meteo info

Airfield Ligthing System

Act./Deact Features

AMS Message Broker

Cancel Operations

Send Priority Messages

Send/Receive Data

18

AMS Case Study

WIS (Weather Information System)

- Gathers local and remote meteorological information
- Sensors transmit weather info to pilots and airport control
- Encompasses a Mgmt system, Comm system, RT computational data, and interface subsystem among others

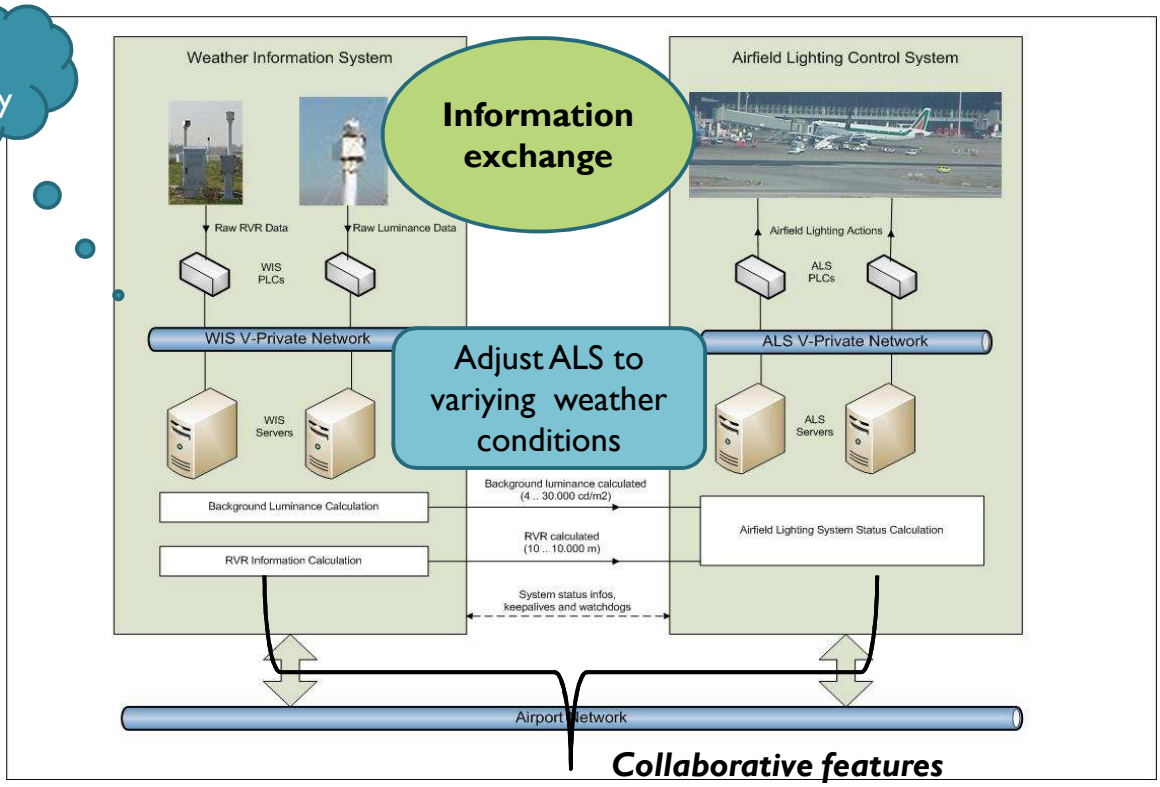
ALS (Airfield Lightning System)

- Monitors airfied ground lightning (AGL) equipment
- Control beacons and airfield runway lights
- Encompasses a SCADA system, Energy subsystem, RT Comm,

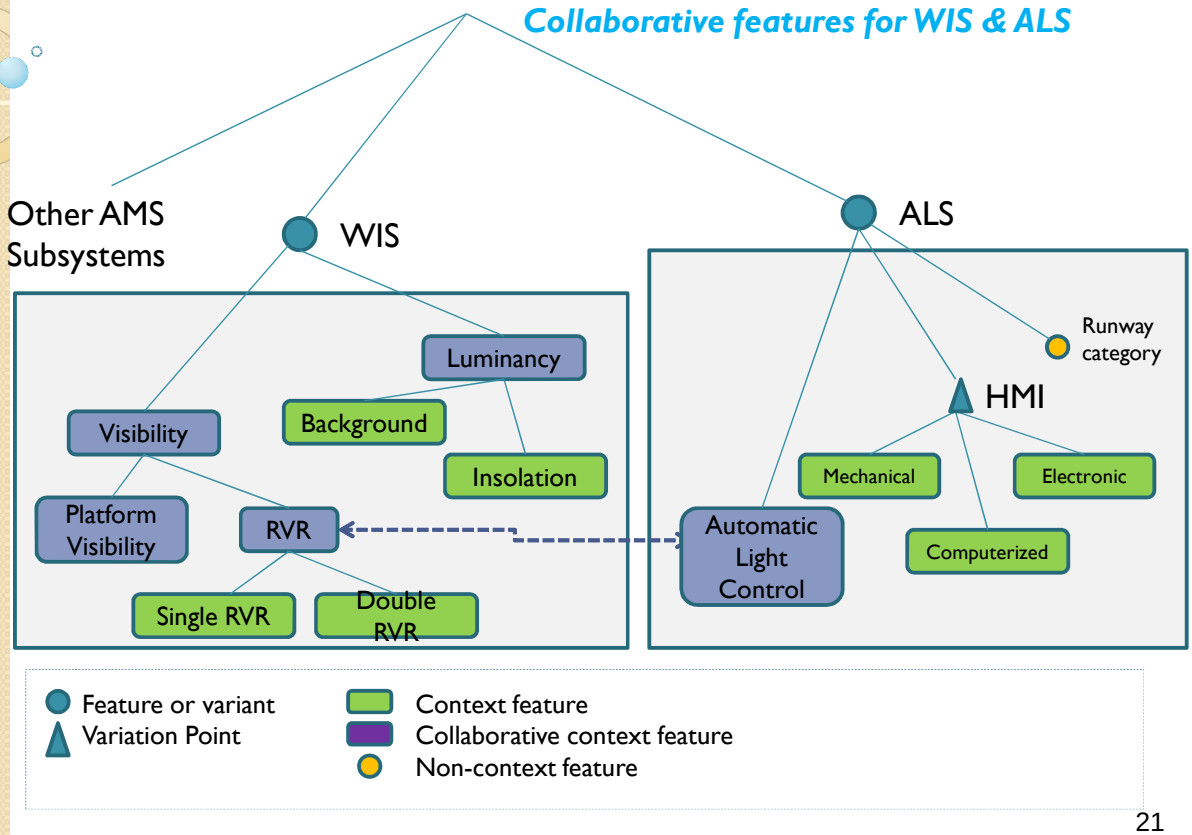
Systems are redundant for safety reasons

AMS Case Study

Low visibility



AMS Case Study



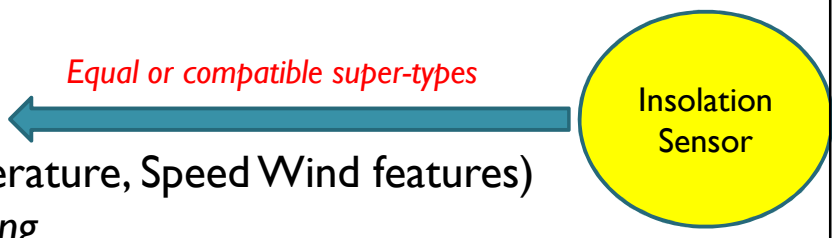
AMS Case Study

AMS super-types for dynamic variability procedures

Classifiers can be used to group context features with a common goal or mission

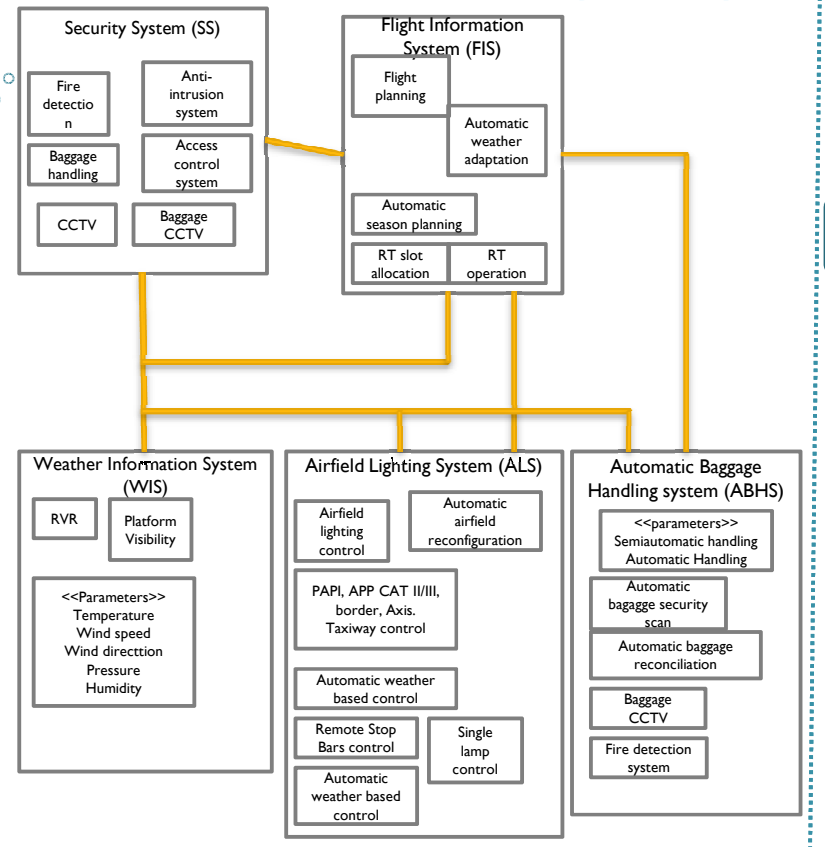
Predefined Super-types (main classifiers) for AMS

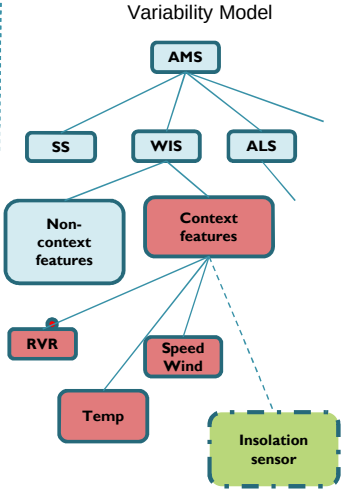
-*Security*
- *Lighting*
- *Weather-info*
  (RVR, Temperature, Speed Wind features)
- *Baggage-handling*
- *Billing*



AMS Case Study

Runtime concerns: Add new features dynamically





Dynamic variability for dynamic reconfiguration adding a new sensor (feature) to the variability model

23

9th VaMoS Workshop, Hildesheim, Germany, January 21-23, 2015

Conclusions

- Initial attempt using context but collaborative features for complex and critical systems with enriched FMs

- Collaborative capabilities play an important role for many criticial SoS and new systems (drones, NASA ANTS)

- Dynamic variaiblity proves a suitable technique for open variability models

- We can ease the evolution of SoS using runtime variability by automating tasks at runtime and for post-deployment procedures

Research Agenda

• Explore other ways to model context variability and test when the proposed two modeling strategies is more suitable

• Need for runtime and online feature checking mechanisms versus offline approaches

•Explore more scenarios for collaborative features

• Test more in depth the use of COP languages with existing AMS middleware

• Dynamic variability (feature replacement) at runtime is a promising and challenging research area

Thank you

Q?