Intelligent Wireless Sensor Network Simulation: Flood Use Case

Réseau IN OVIVE 2 décembre 2016

PhD Jie SUN

Gil De SOUSA, Catherine ROUSSEY, Jean-Pierre CHANET, François PINET, Kun Mean HOU

Outlines

- Context Aware System
- New Formalisation of Context
- Flood Use Case
- Simulation Tool
- Experiments based on data of Orgeval watershed

Definitions of Context

- Context

  "Context is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and the application themselves" (Abowd et al., 1999)

- Low level context

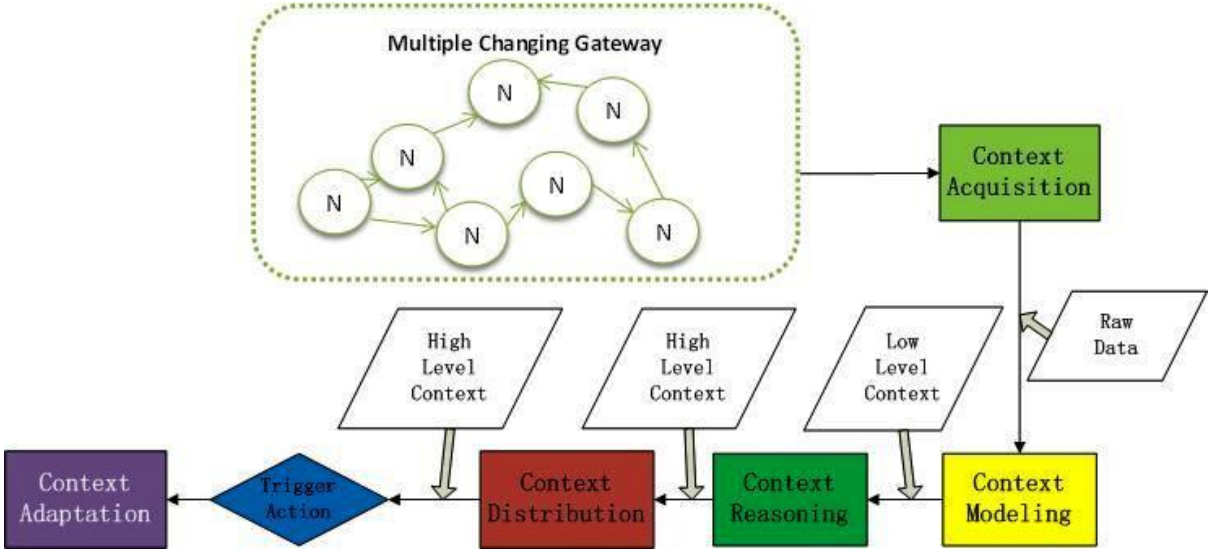
  corresponds to the raw data acquired by sensors or static data provided by users.

- High level context

  is computed from the low level one, with more informative data associated to the application and the use

Adaptive Context Aware System

Several processes



Adaptive Context Aware System

Context acquisition: collecting raw data and metadata that are useful to build the context.

Context modelling: organisation of the collected data through a specific context data model. The process gives an interpretation to each raw data. For example, the value 24 becomes the measurement of the outdoor temperature in degree Celsius. This process builds the low level context. This process is also called annotation or tagging.

Context reasoning: the high level context is computed or inferred from the low level one. This process can imply different approaches based on machine learning or rule engine.

Context distribution: diffusion of the high level context to the different consumers, for example, the end user or any system components that are able to adapt their actions according to the current context.

Context adaptation: actions to adapt any system components according to context changes

New Formalisation of Context: our Definitions

- State

  “a qualitative data which changes over times (summarizing a set of information)”
- Context

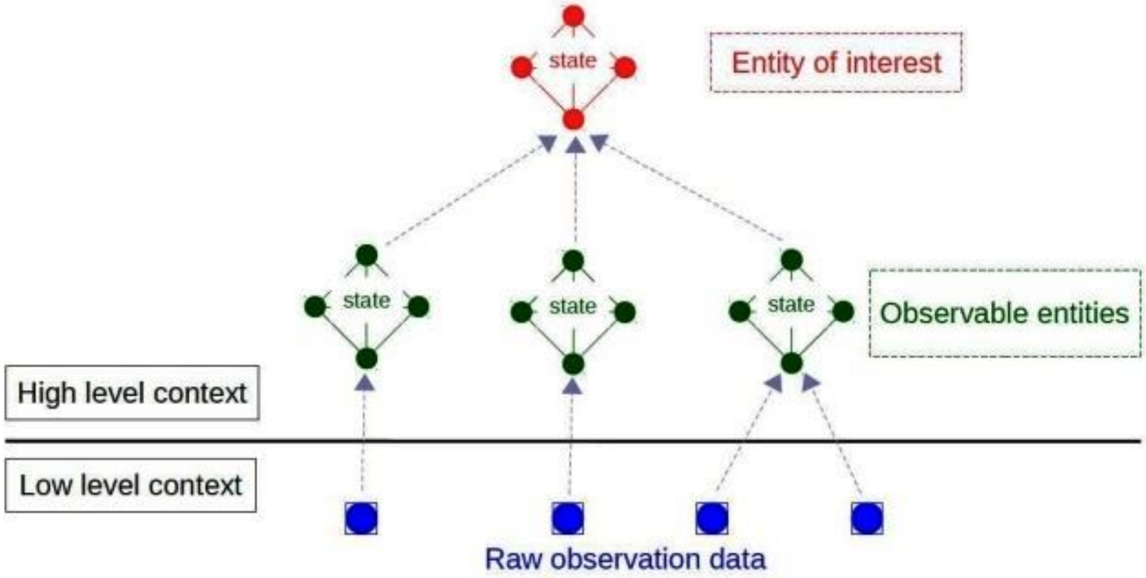
  “a set of entities characterized by their state, plus all information that can help to derive any state changes of these entities”
- Observable entity

  “entity that is directly observed by sensors”
- Entity of interest

  “entity whose characterisation is obtained from one or many other entities and required by the application”

Illustration of our Entity Classes

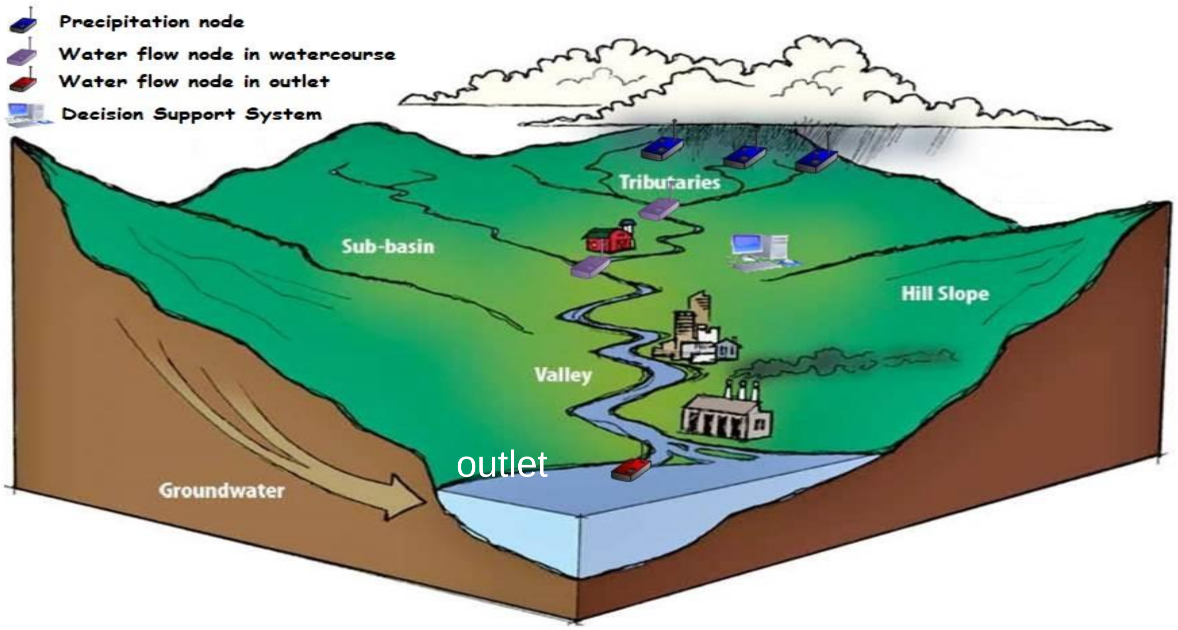
Two types of entities:
Observable Entity
Entity of Interest



Benefits of Our Formalisation

- Clarify the reasoning process
- “Distribute” the reasoning process in several steps :
  - Infer the state of Observables Entities
  - Infer the state of Entity of Interest from the state of Observable Entities
- Make the management of rules easier
- Distribute the reasoning process in different components of the system

Flood Context Example: Watershed



Source (Heathcote, 1998) Primary components of a watershed

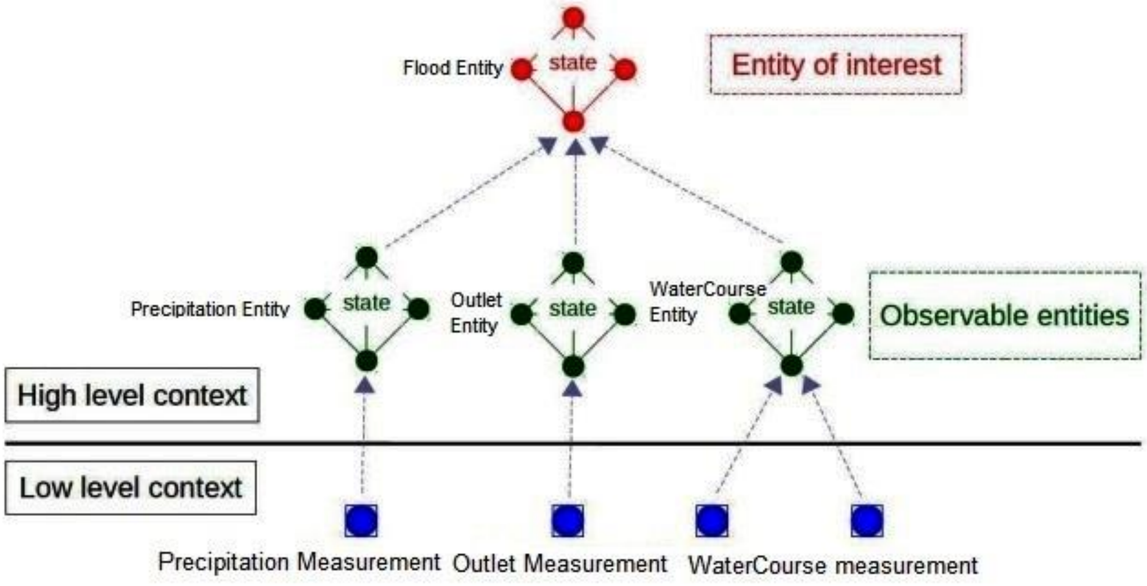
Flood Context Example Entities

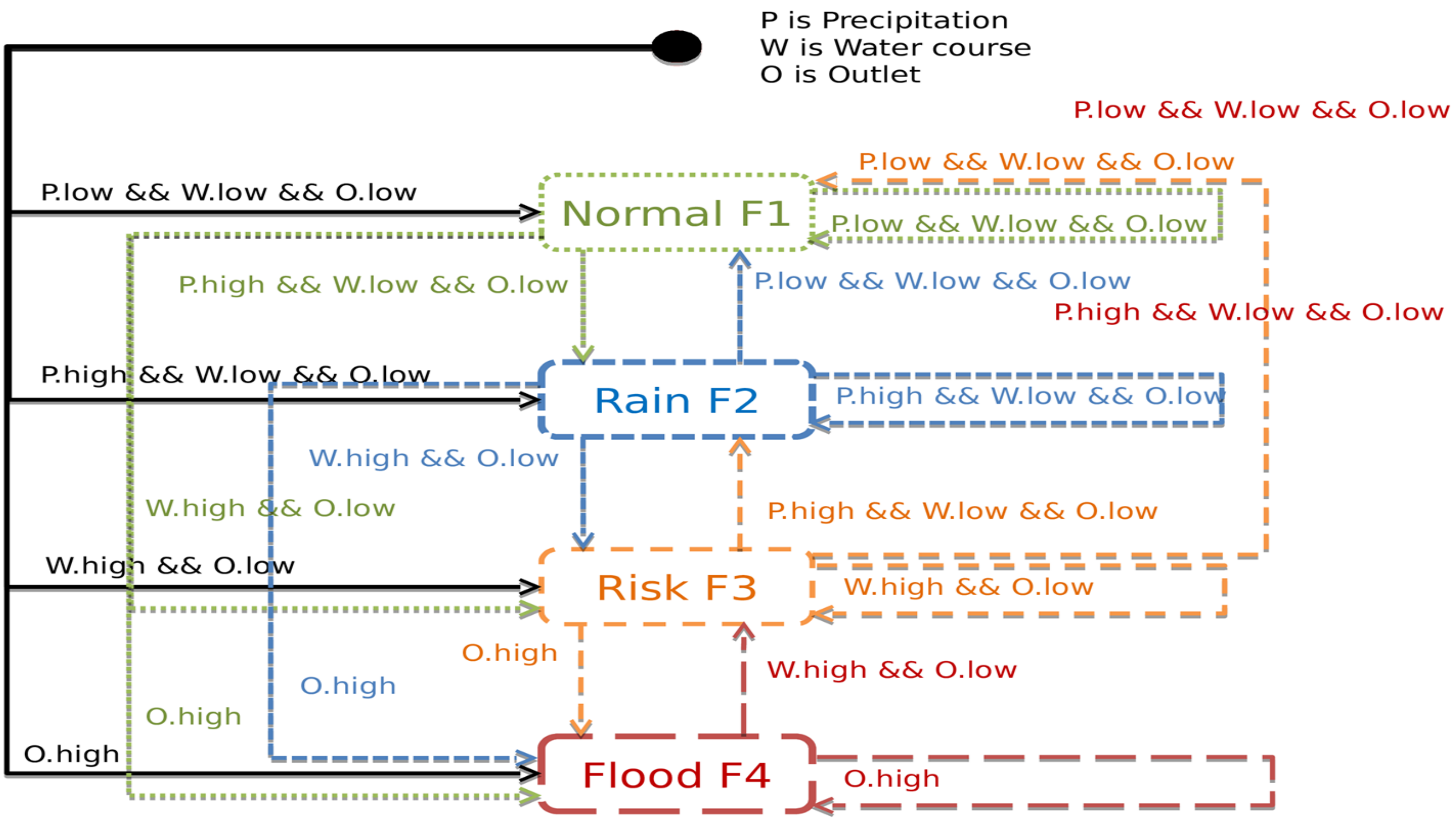
Observable Entities:

1. Precipitation
2. Watercourse
3. Outlet

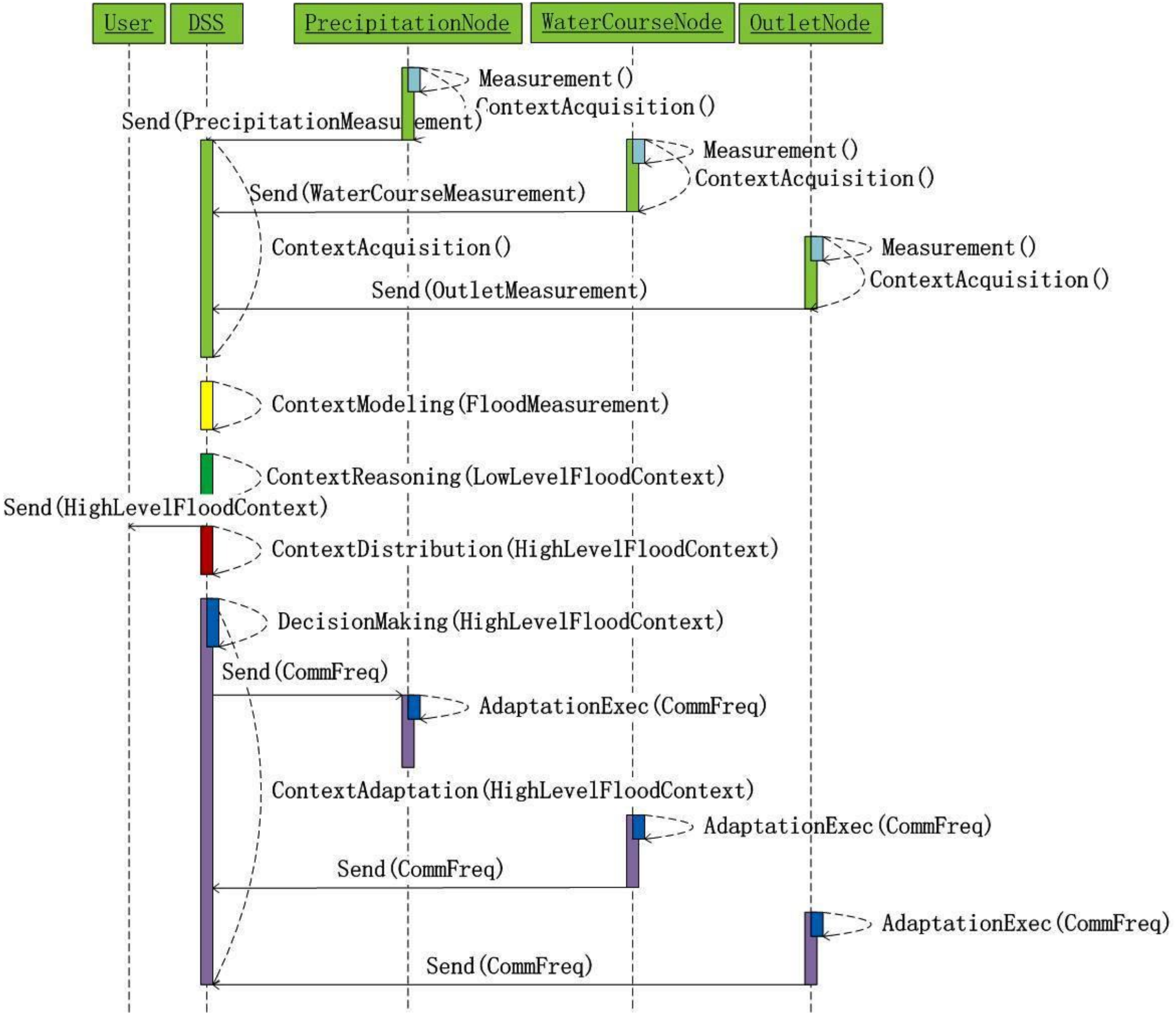
Entity of Interest:

1. Flood



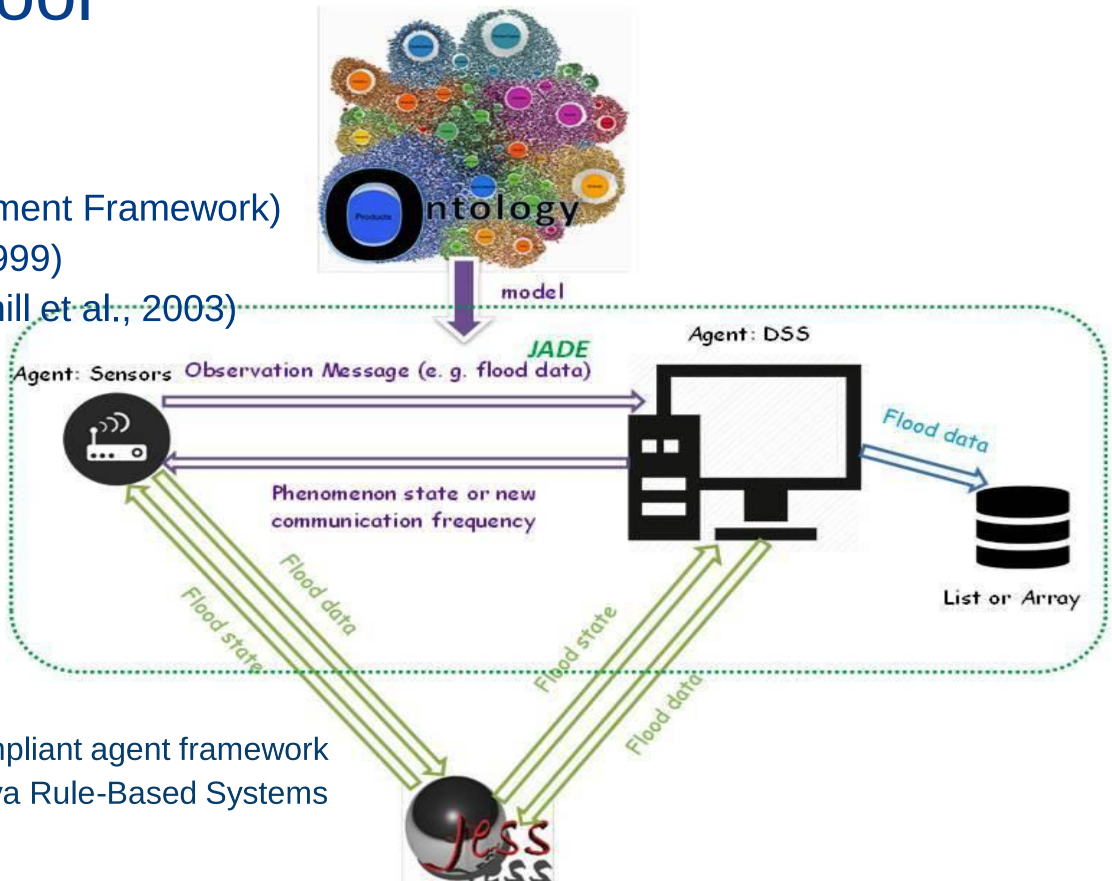


P is Precipitation
W is Water course
O is Outlet
P.low && W.low && O.low
P.low && W.low && O.low
P.low && W.low && O.low
Normal F1
P.low && W.low && O.low
P.high && W.low && O.low
P.low && W.low && O.low
P.high && W.low && O.low
P.high && W.low && O.low
Rain F2
P.high && W.low && O.low
W.high && O.low
W.high && O.low
P.high && W.low && O.low
W.high && O.low
Risk F3
W.high && O.low
O.high
O.high
W.high && O.low
O.high
O.high
Flood F4
O.high


User
DSS
PrecipitationNode
WaterCourseNode
OutletNode
Measurement()
ContextAcquisition()
Send(PrecipitationMeasurement)
Measurement()
ContextAcquisition()
Send(WaterCourseMeasurement)
ContextAcquisition()
Measurement()
ContextAcquisition()
Send(OutletMeasurement)
ContextModeling(FloodMeasurement)
ContextReasoning(LowLevelFloodContext)
Send(HighLevelFloodContext)
ContextDistribution(HighLevelFloodContext)
DecisionMaking(HighLevelFloodContext)
Send(CommFreq)
AdaptationExec(CommFreq)
ContextAdaptation(HighLevelFloodContext)
AdaptationExec(CommFreq)
Send(CommFreq)
AdaptationExec(CommFreq)
Send(CommFreq)

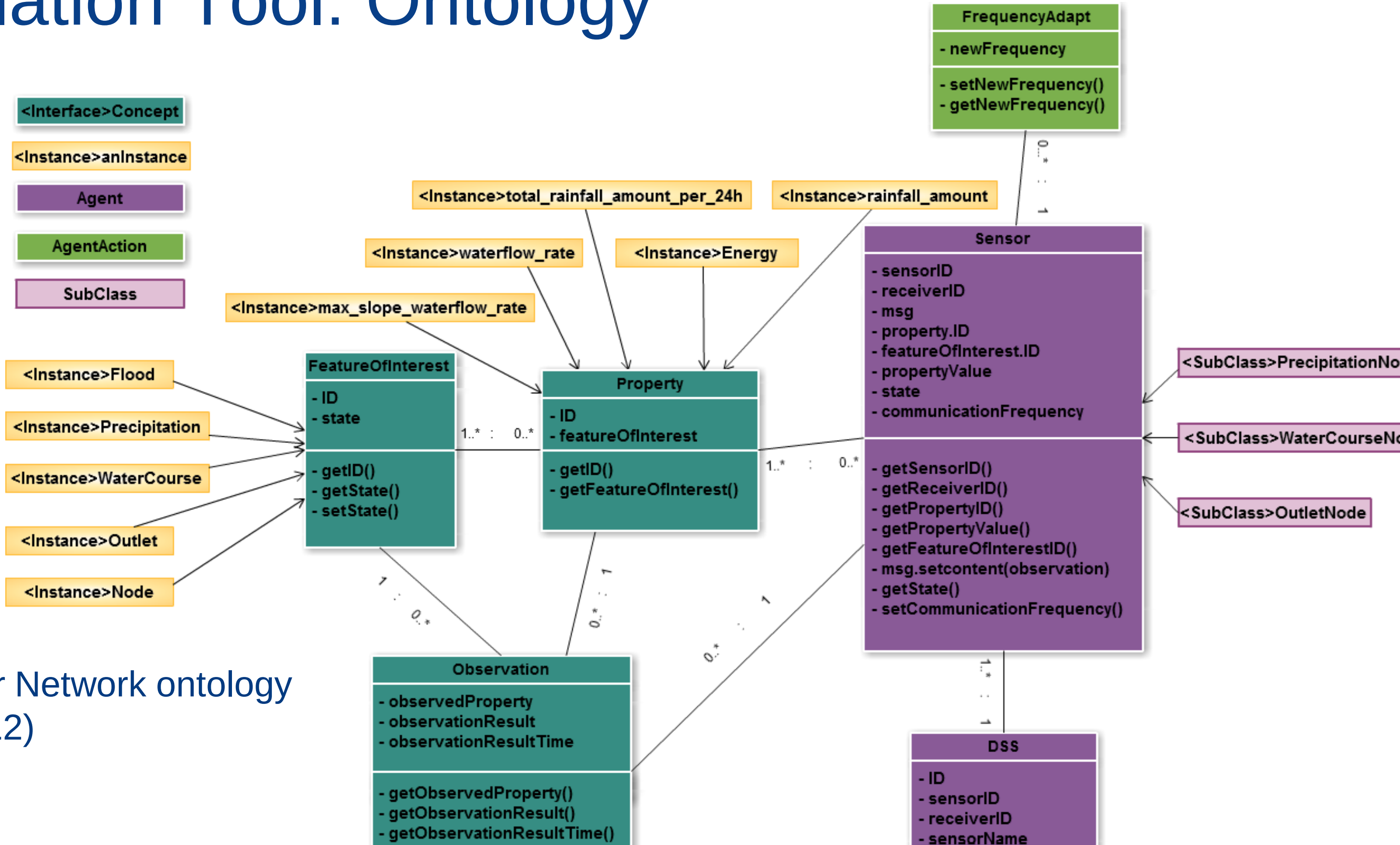
Simulation tool

- JADE (Java Agent DEvelopment Framework) (bellifemine et al., 1999)
- Jess rule engine (friedman-hill et al., 2003)



(Bellifemine et al., 1999) JADE--A FIPA-compliant agent framework
(friedman-hill et al., 2003) Jess in Action: Java Rule-Based Systems

Simulation Tool: Ontology



Based on Semantic Sensor Network ontology (SSN) (Compton et al., 2012)

Simulation Tool: Jess Rules Engine

Rule deducing the NORMAL state of Flood entity

```
(defrule floodState_NormalF1
(declare (salience 10))
?p <- (pluvio {state == low})
?w <- (WaterCourse {state == low})
?o <- (outlet {state == low})
?f <- (flood)
=> ( modify ?f (state f1))
)
```

Simulation: Data source

- French Orgeval watershed managed by Irstea (Agir pour Orgeval., 2012)
  - 3 weather stations
  - 3 stream gauges
  - Année 2007 (threshold calculation) et 2008 (tests)
- Configuration
  - Aggregation functions of measurements for wireless sensor node : total amount precipitation for 24 hours, max slope of waterflow rate from 6 hours
  - Aggregation functions for the DSS: sum, max
  - Thresholds for each type of entities

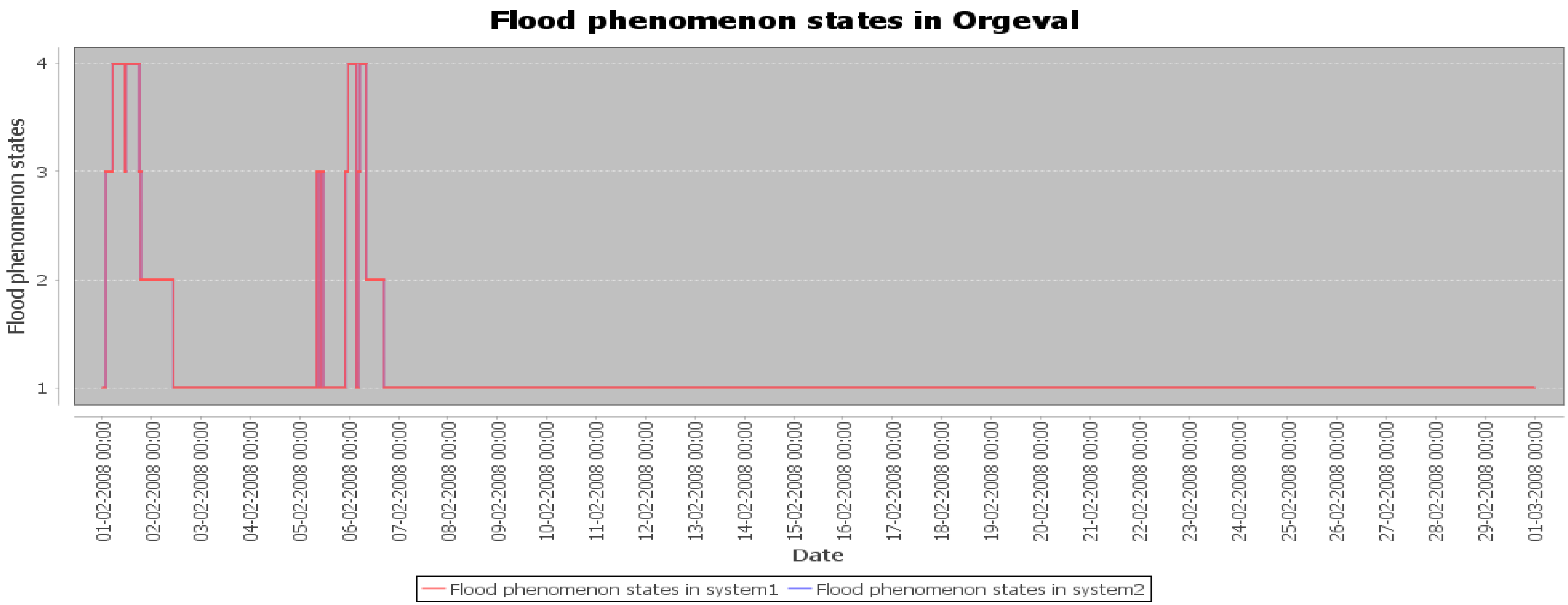
(Agir pour Orgeval., 2012) http://www.agir-pour-orgeval.fr/index.php/schema-regional-eolien-dile-de-france-dou-vient-le-vent/

Simulation: Defined systems

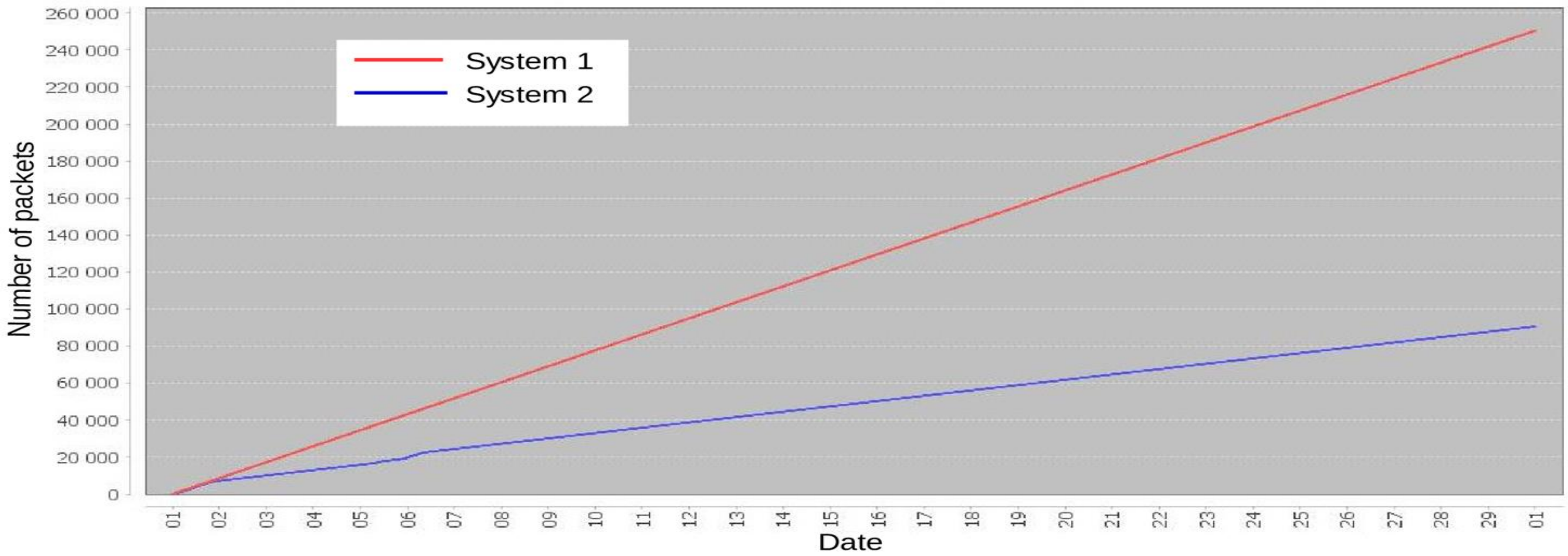
- **System 1**
  - Classic Context-aware system
    - Acquisition frequency = Raw data acquiring per minute
    - Acquisition frequency = Transmission frequency
- **System 2**
  - Adaptive Context-aware system
    - Acquisition frequency = Raw data acquiring per minute

Flood State	NORMAL	RAIN	RISK	FLOOD
Transmission Frequency	1/3*Acquisition Frequency	1/2*Acquisition Frequency	Acquisition Frequency	Acquisition Frequency

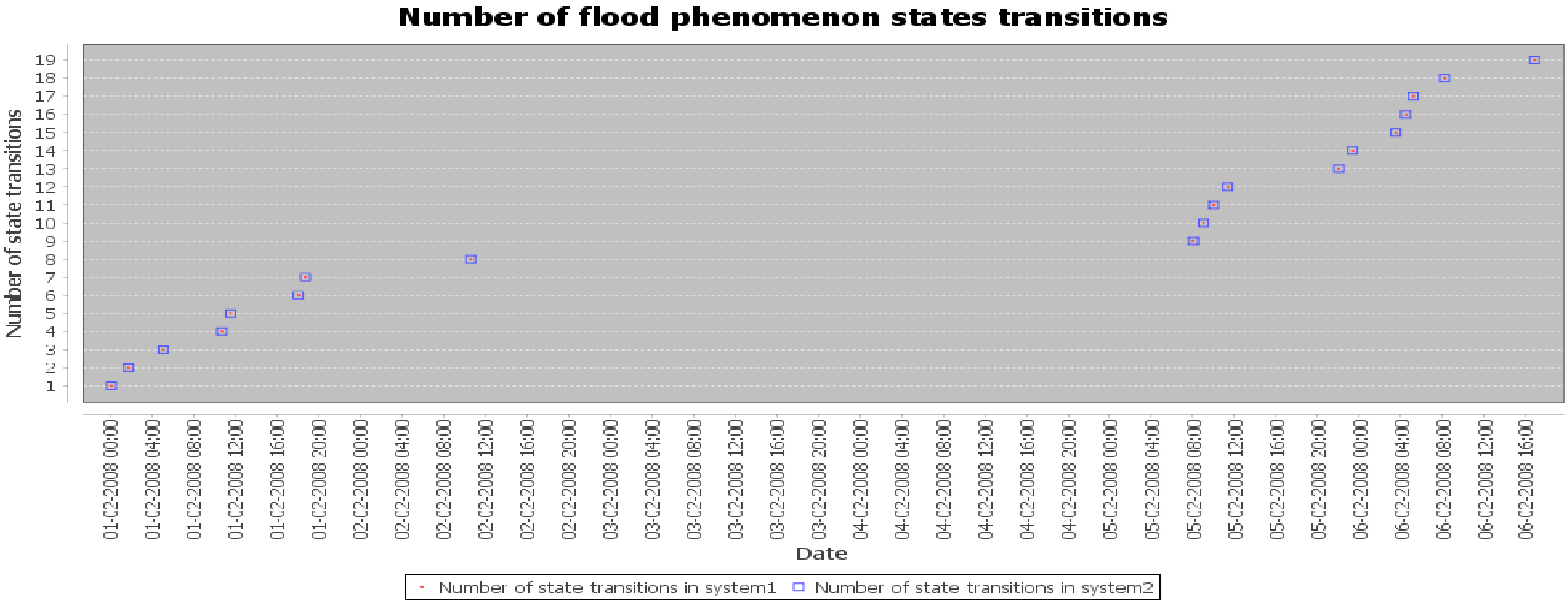
Results: Flood phenomenon states



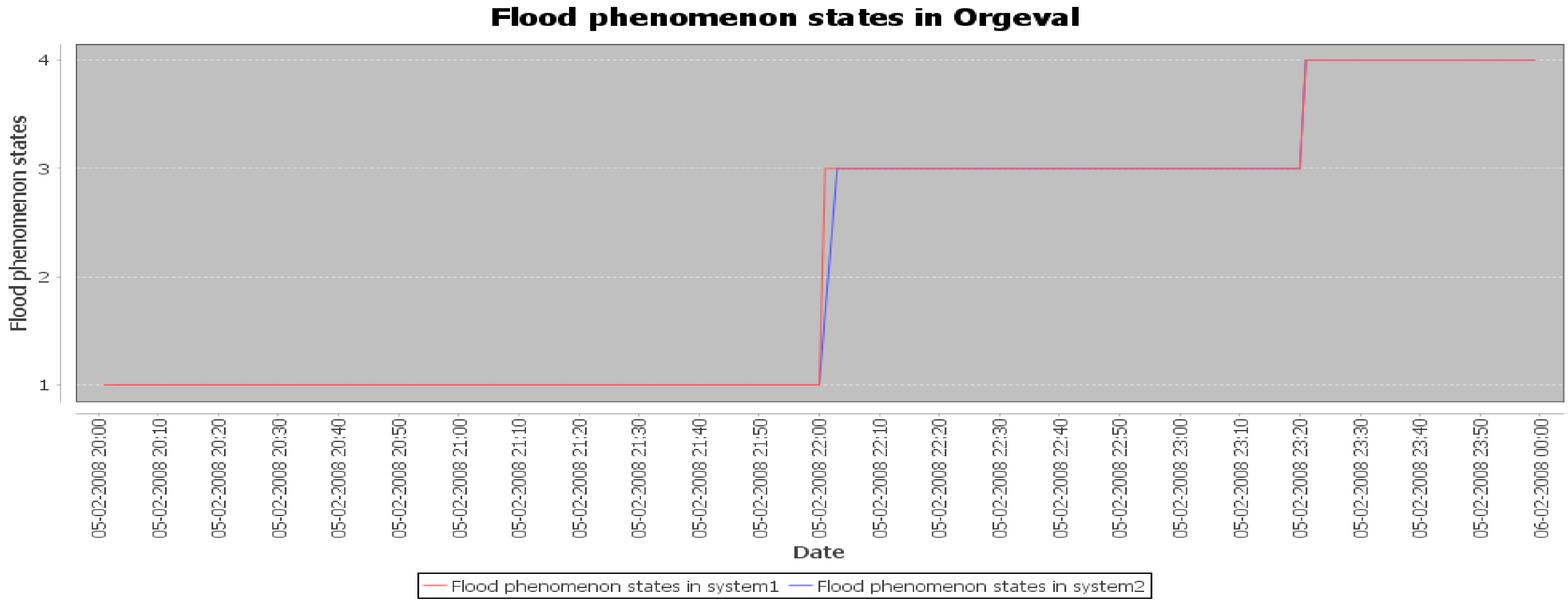
Results: Number of transmitted packets



Results: Number of Flood phenomenon state transitions



Results: Examples of flood phenomenon state timestamp difference



Conclusion

- **Advantages**
  - Unified way to deal with all the components/entities of an observation process (WSN and studied phenomenon)
  - Used in different application topics related to agriculture or environment
- **Future work**
  - Different scenarios to solve the delay of flood risk events
  - Different scenarios taking into account limited resources

Thank you for your attention !

This research is partly funded by the grant of the French Auvergne region, and now in the new Auvergne-Rhone-Alpes region and, the grant of the European Regional Development Fund (ERDF). The authors would like to thank the team of the Orgeval observatory for their help.