Complex Sensing Event Process of IoT Application Based on EPCglobal Architecture and IEEE 1451

Chao-Wen Tseng, Chih-Ming Chang, and Chua-Huang Huang
Department of Information Engineering and Computer Science/
Intelligent Identification Technology and Research Center
Feng Chia University, Taichung, Taiwan

2012.10.25

Outline

- Introduction
- IoT Framework and Management Platform
- Complex Sensing Event Process of EcoPark Application
- Implementation of EcoPark Application
- Conclusions and Future Works

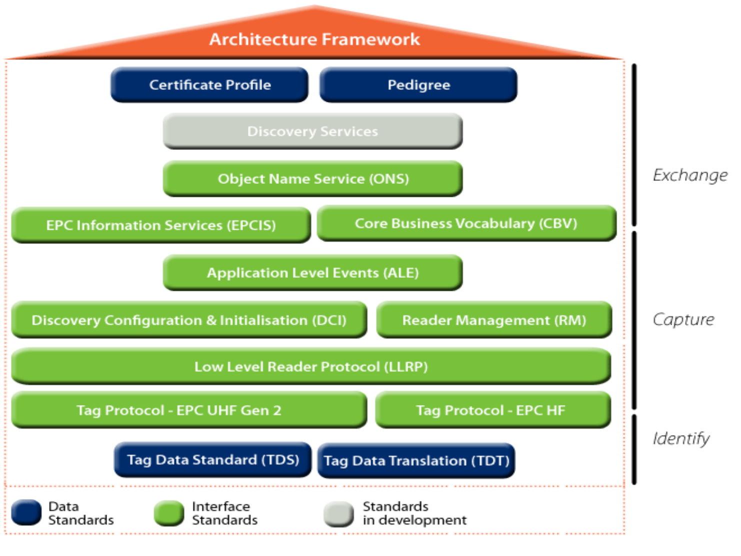
Introduction

- For achieving intelligent capability, an IoT application system must be able to
  - Analyze Object Data
  - Reason Sensing Events
  - Trigger Responding Actions
- This paper presents：
  - An IoT framework based on EPCglobal architecture and IEEE 1451 standard
  - An IoT management platform to verify the IoT framework
  - An EcoPark application to simulate and demonstrate the mechanism of complex sensing event process

Introduction

➢EPCglobal Architecture Framework

- EPCglobal was acquired by GS1 in 2003 and has released a collection of standard documents
- ALE middleware has the functions of filtering and consolidating EPCs and related data from one or more data sources.
- EPCIS event repository is located between the capture layer and the exchange layer of EPCglobal architecture framework.

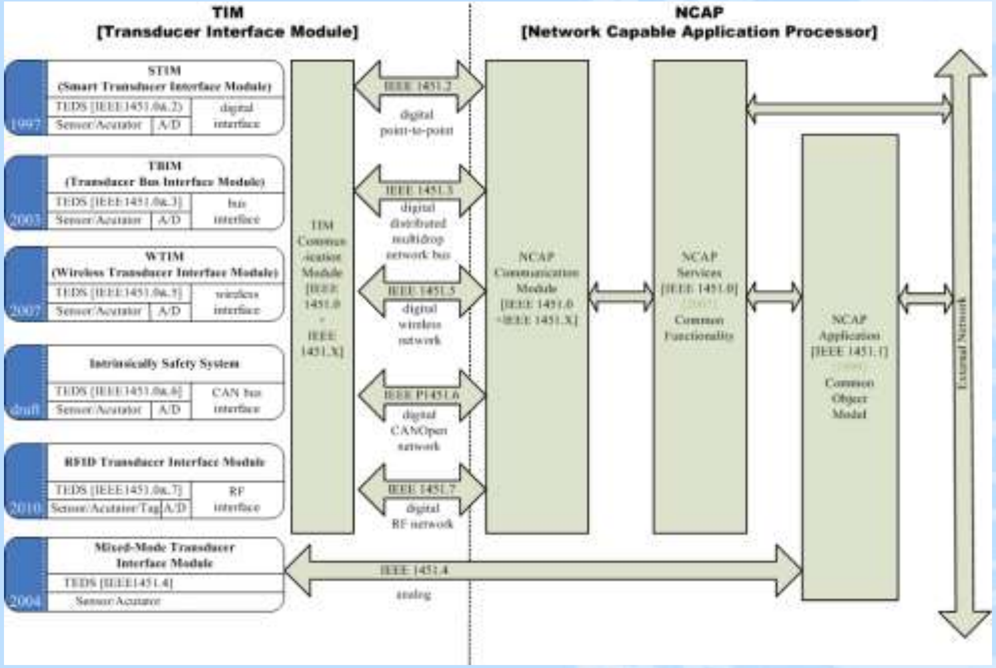


[Source: GS1]

Introduction

➢IEEE 1451 Standard Series

- IEEE 1451 is a series of smart transducer standards to provide a unified way to access any type, manufacturer, and wired or wireless sensors.
- IEEE 1451 standard series can be divided into two main parts: Transducer Interface Module (TIM) and Network Capable Application Processor (NCAP).

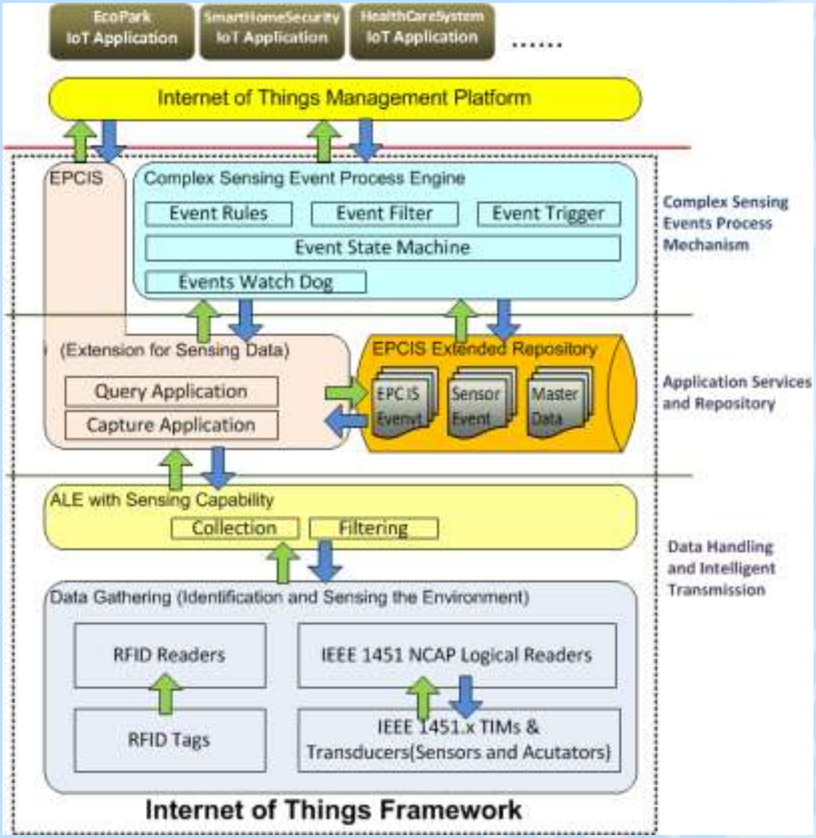


Introduction

- Complex event processing is a technology originally developed for extracting information from distributed message-based systems and widely applied to various fields.
- The perspective of IoT is ：
  - *One Paradigm, Many Visions*
  - Most of RFID applications focus on identifying items but sensing the environment is lack of.
  - Transducers (sensors and actuators) and intelligent communication technology will also play the other crucial roles in the IoT systems.

IoT Framework and Management Platform

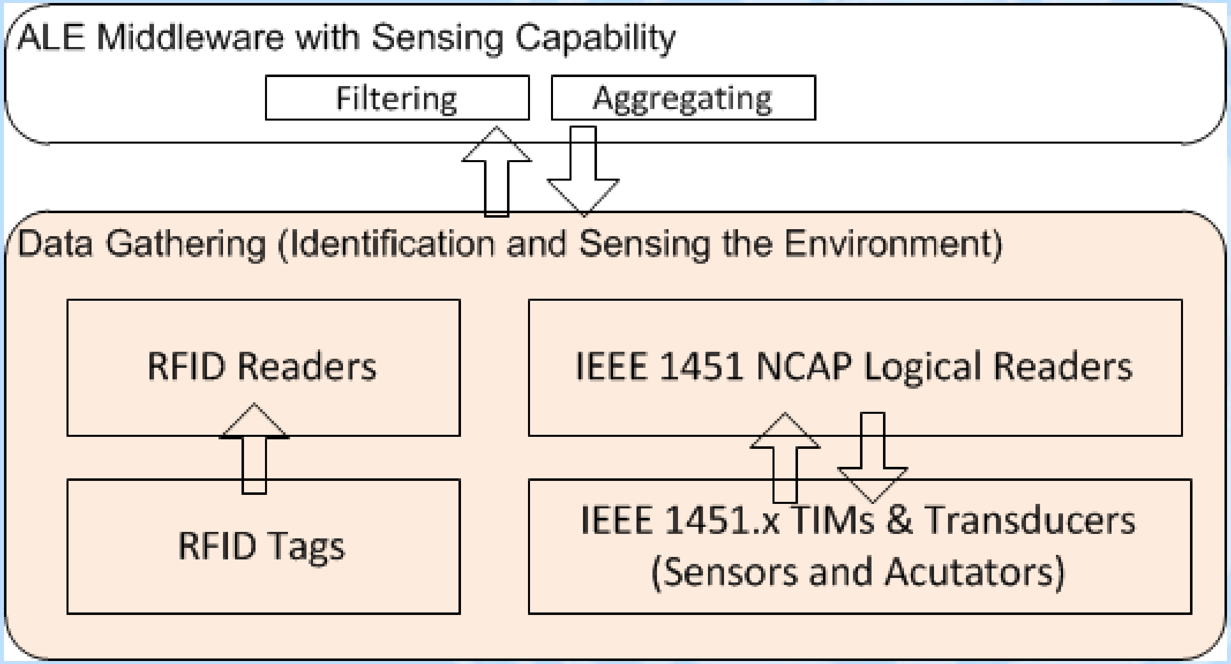
- Using the EPCglobal architecture framework as the foundation, and integrates with IEEE 1451 standards.
- The platform architecture can be built on a variety of network technologies and development tools.



IoT Framework and Management Platform

① Data Collection and Intelligent Transmission

- ✓ The abstraction of RFID items or transducers must be considered at this physical layer.
- ✓ For the general purpose of this framework, we assume all types of RFID tags can be used, not only C1G2.
- ✓ IEEE 1451 supports a plug and play mechanism for smart transducers.



IoT Framework and Management Platform

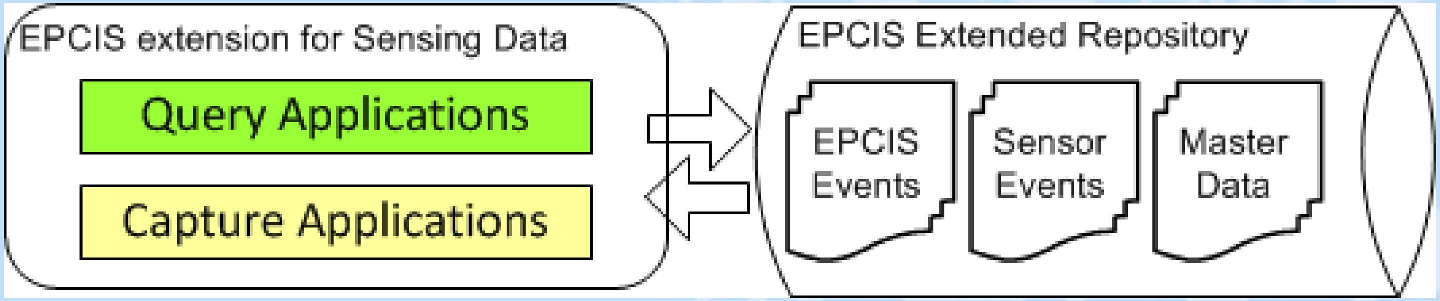
① Data Collection and Intelligent Transmission

- ✓ Through RFID and the IEEE 1451 standards, the application can identify items and sense the environment in the IoT.
- ✓ We extend ALE middleware for gathering, collecting and filtering the data stream of identification and sensing the environment.
  - – We stretch the ALE by viewing the NCAP as a customized reader to fit in the EPCglobal architecture framework.
  - – These data collected from readers and NCAP are sent to the ALE middleware with sensing capability, which performs filtering and collecting operations of data.
  - – ALE middleware will generate the ECReport according to the event cycle definition, data obtained model (Subscribe, Poll, Immediate), and data filtering and gathering rules.

IoT Framework and Management Platform

② Application Services and Event Repository

- ✓ EPCIS Extended Repository
- ✓ Application Services
  - A. Capture application is used to analyze ECReport that received from the ALE middleware and to create simple events to for EPCIS.
    - » For handling sensing data, sensor event data is appended to master data in event repository.
    - » It enhances the ability of recording the sensing events and the measured values from sensors.



IoT Framework and Management Platform

② Application Services and Event Repository

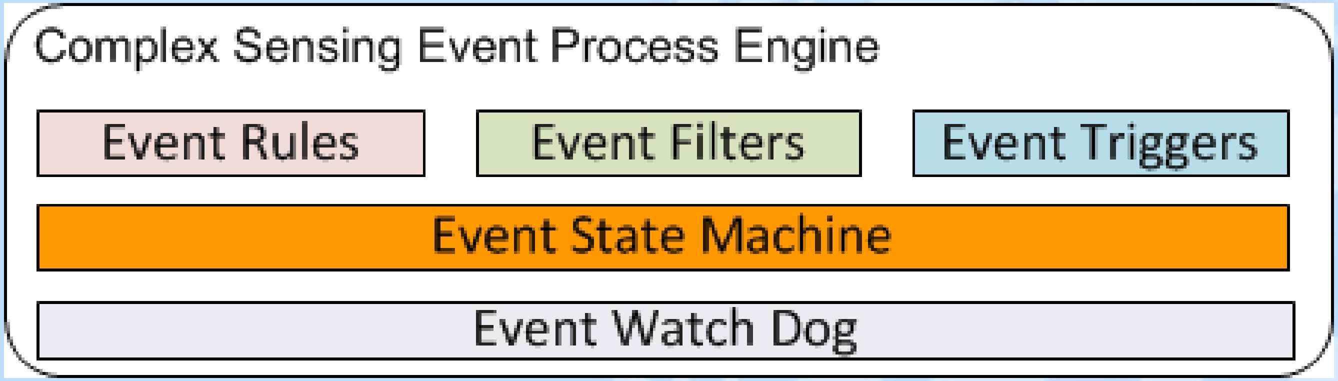
B. Query application provides the relevant APIs to query events that are stored in the repository.

- » *real time and historical events query* by *event process engine*
  - Query application search for simple events to form real time event stream immediately and continuously.
  - It provides event process engine a feature to perform real time analysis and event process.
  - It also provides historical data to the upper layer of applications that support statistical analysis of historical events.
- » *business vocabulary query* according to the *master data*
  - According to the pre-defined master data in EPCIS repository, different types of event data can be generated and stored in the event repository.

IoT Framework and Management Platform

③ Complex Sensing Event Process Mechanism

- ✓ The mechanism of complex sensing event process uses the event watch dog to receive real time event stream from EPCIS.
- ✓ Complex event is an event that are generated or aggregated by other events.
- ✓ To find out the significant events (event pattern) from multiple events, and do the follow-up action if they satisfy the event pattern.



IoT Framework and Management Platform

③ Complex Sensing Event Process Mechanism

- ✓ The core handling modules in event process engine consist of:

A. Event Filter

» *When the simple event stream coming from middleware and does not meet any predefined event patterns, then they are dropped out from the simple events.*

B. Event Rules

» *Event process engine uses the rules language and the state machine model to describe the event processing rules and rule-based reasoning.*

C. Event State Machine

» *The results can be sent to event processing engine to facilitate further reasoning and decision making.*

D. Event Trigger

» *When an event pattern meets the specific conditions, action is triggered by pre-defined rules to make the appropriate response.*

Complex Sensing Event Process of EcoPark Application

- EcoPark Application
  - It is designed to demonstrate the mechanism of complex sensing event process.
  - This application of reusable energy resources in EcoPark is divided into electricity and water.
  - It can reduce the manual operations of park management effectively and support the existing system.
  - The complex sensing event process is implemented for supporting the IoT management platform.
  - Two types of simple event are captured in EPCIS：
    - Object Events
    - Sensor Events

Complex Sensing Event Process of EcoPark Application

- Simple Events of EcoPark Application

Park Resources	Simple Event
Power Resource	EA_1: Detection of battery storage capacity. EA_2: Detection of LED street light on. EA_3: Detection of LED spotlight on. EA_4: Detection of start of fountain.
Water Resource	EB_1: Set tank water level detection. If the water reservoir level is high, the water flows to the ecological pond; if reservoir water level is low, the water supply switching device is switched to tap water.
Context-aware Environment	EC_1: Air temperature detection. EC_2: Soil moisture detection. EC_3: Detect pedestrians passing. EC_4: Detect ambient light intensity (day and night).

Complex Sensing Event Process of EcoPark Application

- Complex Sensing Event Operators

Operator	Notation	Meaning
Disjunction	$(E_1 \vee E_2)$	Event E_1 or E_2 occurs.
Conjunction	$(E_1 \wedge E_2)$	Events E_1 and E_2 occur.
Negation	$(!E)$	Event E does not occur.
Before	*Before*(E, t)	Event E occurs before time t.
After	*After*(E, t)	Event E occurs after time t.
Between	*Between*(E, t_1, t_2)	Event E occurs between time t_1 and t_2.
Interval	*Interval*(E, p)	Event E occurs within time interval p.
Sequence	$(E_1; E_2)$	The sequence relationship between the events: event 1 occurs, then event 2.
List	(E_1, E_2, E_3)	There is no sequence relationship among the events: events 1, 2, 3 subject to the conditions of time occur.

Complex Sensing Event Process of EcoPark Application

- An example of the EcoPark EPCIS sensor event data


```
- <SensorEvent>
    <eventTime>2012-4-30T20:33:31.116-06:00</eventTime>
    <sensorID>A001</sensorID>
    <action>ADD</action>
    <sensorType>temperature sensor</sensorType>
    <measuredUnits>celsius</measuredUnits>
    <measuredValue>26.28</measuredValue>
  - <readPoint>
      <id>urn:epc:id:sgln:0614141.07347.124</id>
    </readPoint>
  - <evLocation>
      <id> urn:epc:id:sgln:0614141.07346.0</id>
    </evLocation>
  </SensorEvent>
```

Complex Sensing Event Process of EcoPark Application

- Trigger Events of EcoPark Application

Park Resource	Trigger Event
Power Resource	*trigger*(*EA*$_a$, *power_to_battery*): Power save to battery . *trigger*(*EA*$_b$, *battery_to_power*): Additional power from the battery. *trigger*(*EA*$_c$, *led_streetlamp_on*): LED street light switch on. *trigger*(*EA*$_d$, *led_spotligh_on*): LED spotlight switch on. *trigger*(*EA*$_e$, *start_fountain*): Start fountain motor.
Water Resource	*trigger*(*EB*$_a$, *rain_to_ecological_pond*): Water flows to Eco Pond. *trigger*(*EB*$_b$, *piped_water_on*): Switching device to tap water. *trigger*(*EB*$_c$, *sprinkler_on*): Start sprinkler watering equipment. *trigger*(*EB*$_d$, *humidifier_on*): Spray mist humidifier device.

Complex Sensing Event Process of EcoPark Application

- **Behavior Description Using Event Process Clause**

  SELECT EVENT <event pattern>
  FROM E(e), event stream data
  WHERE <event parameters condition>
  TIME <Before/After/Between/Interval (time express)>
  TRIGGER ACTION <do something>

- **For Example**

  Every 15 minutes, the system automatically checks whether the relative humidity of soil moisture in garden is below 20%. If the above criteria meet, it starts the sprinklers.

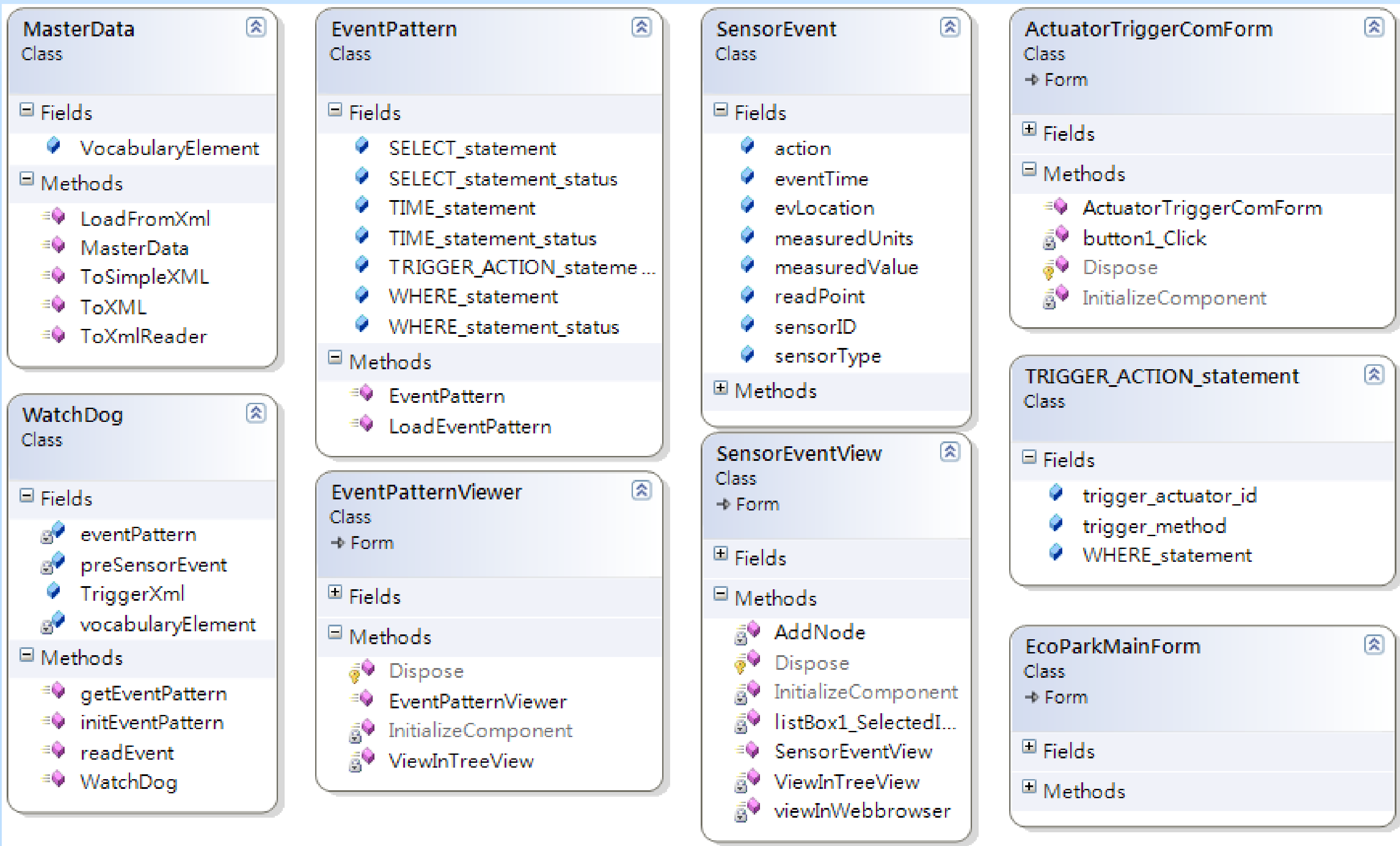
  SELECT EVENT (EC2)
  FROM event stream data
  WHERE EC2.d<20 //relative humidity below 20%
  $\wedge$ (EBc.evloc=EC2.evloc)
  TIME Interval 15 // (minute)
  TRIGGER ACTION trigger(EBc, sprinkler_on)

Implementation of EcoPark Application

➢The IDE of IoT Management Platform

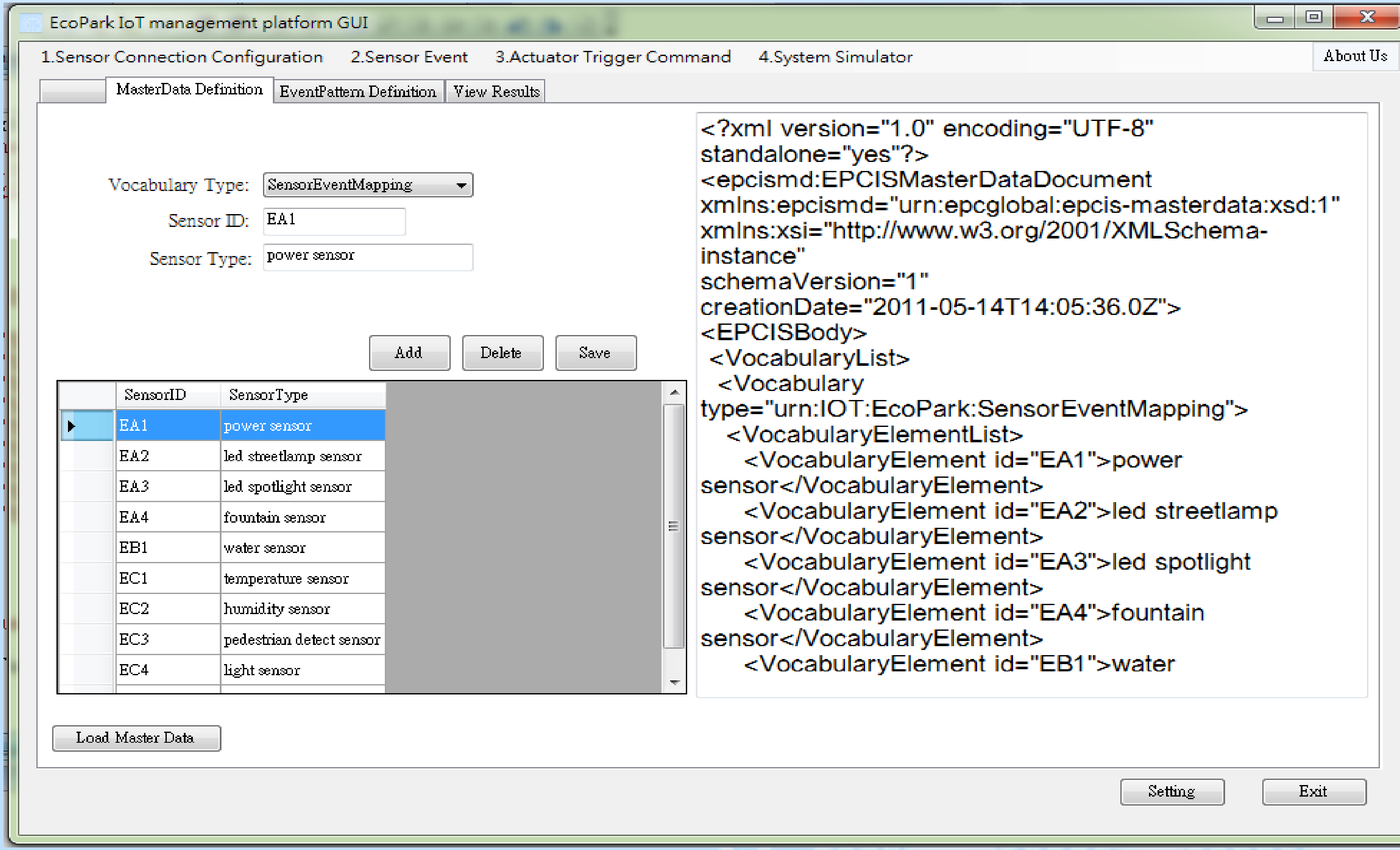
Implementation of EcoPark Application

➢Core Classes of IoT Management Platform



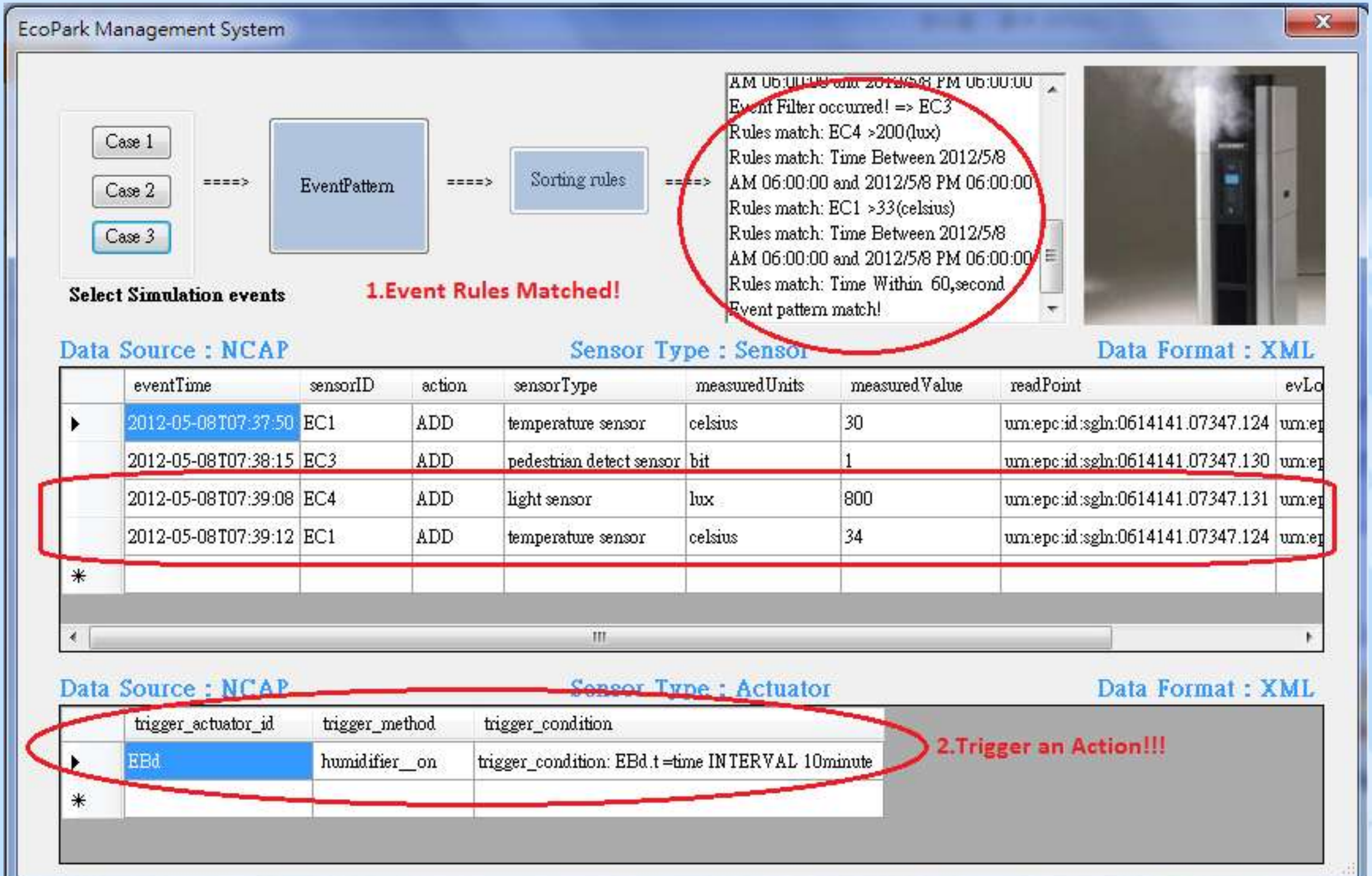
Implementation of EcoPark Application

➢User Interface of Master Data Definition



Implementation of EcoPark Application

➢Simulation Result of EcoPark IoT Application



Conclusions and Future Works

- This paper proposed IoT framework based on EPCglobal and IEEE 1451 standards and toward to an open environment.
- The EcoPark application based on IoT management platform shows the feasibility of IoT framework and the mechanism of complex sensing event process.
- The detailed extension on design issues：
  - RFID and Sensor Integration
  - ALE with Sensing Capability
  - EPCIS Repository Extension for Transducer