Semantic-driven Configuration of Internet of Things Middleware

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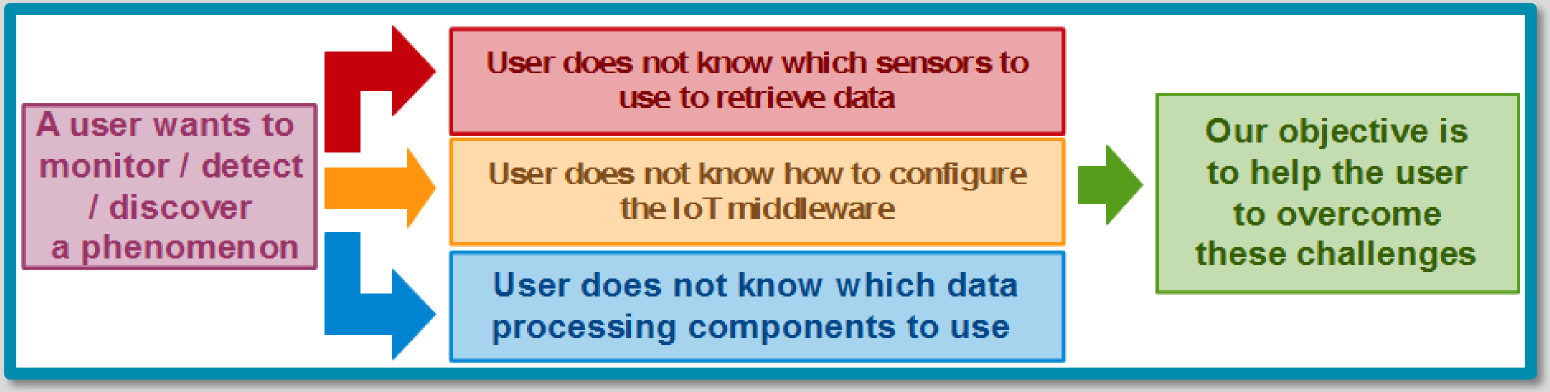
OPENIoT

Agenda

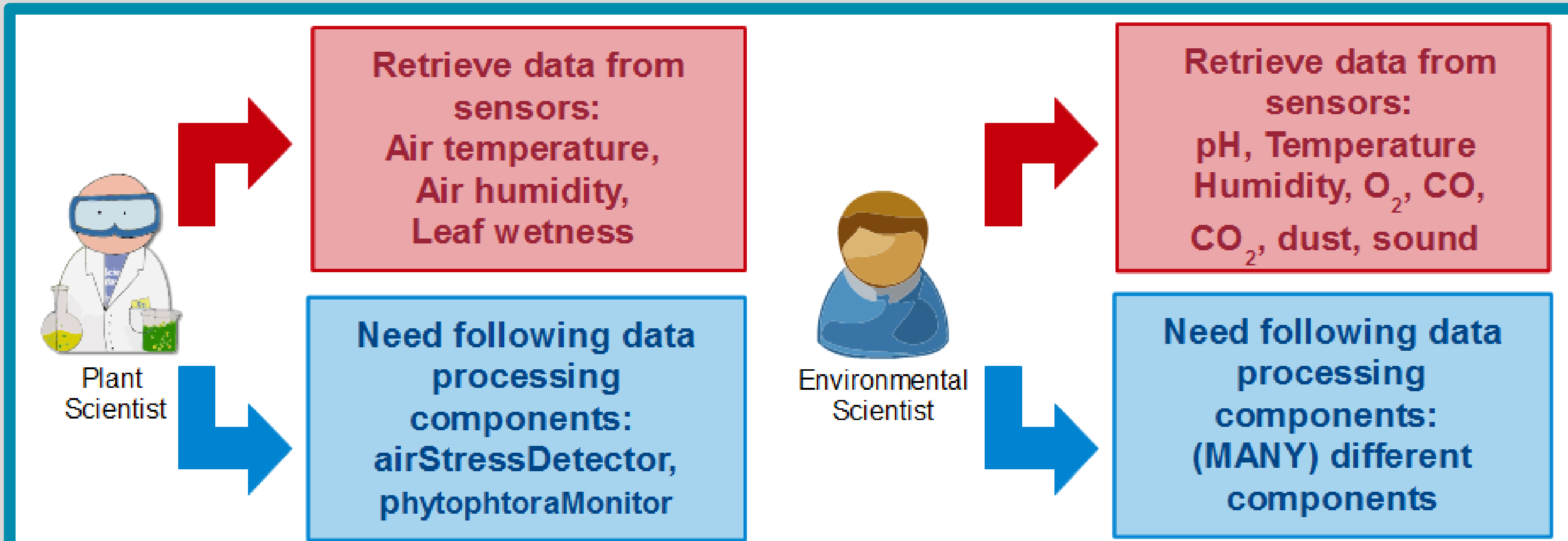
- Background and The Problem
- Functional Requirements
- Objectives and Assumptions
- Proposed Solution: CASCoM
- Implementation
- Experimentation, Evaluation and Results
- Future Work and Research Directions

Background and The Problem

- Large number of sensors →
  Hard to keep track of capabilities [Descriptions]
- IoT middleware hard to use →
  Too complex for non technical users
- Configuration is hard / time consuming even for IT personnel
- Users don't want to deal with technical details



Functional Requirements

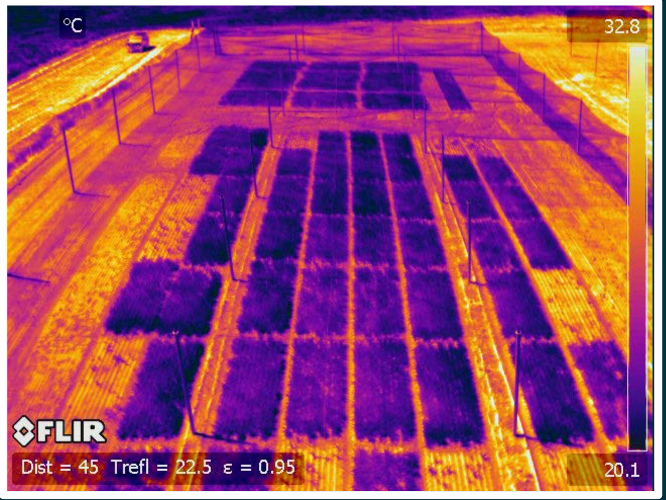


(a) User Case 1 (Agriculture): A plant scientist wants to monitor whether the experimental crops can be infected by *Phytophtora* disease

(b) User Case 2 (Environment): A environmental scientist wants to monitor environmental pollution in Canberra, Australia

- IF **airTemperature** $< \alpha$ AND **airHumidity** $< \beta$ THEN **airStress** level = low ELSE **airStress** level = high
- IF **airStress** = high AND **leafWetness** $> \delta$ THEN *PhytophtoraDisease* = Can-be-infected ELSE = Cannot-be-infected

Real World Scenario



- **Grains Research and Development Corporation (GRDC) trials plant varieties in very many 10m x 10m plots across Australia.**

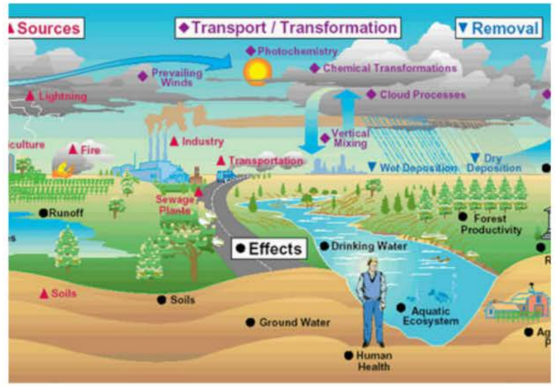
- **Every year, Australian grain breeders plant up to 1 million plots across the country to find the best high yielding**

- **Issues in current practices:**
  - **Site visits are expensive and time-consuming (e.g., 400km away)**
- **Lack of accurate information limits the quality of results**

Objectives and Assumptions

Phytophtora Monitoring

- Air Stress
- Phytophtora Disease
- Location
- Battery Level



Air Pollution Monitoring

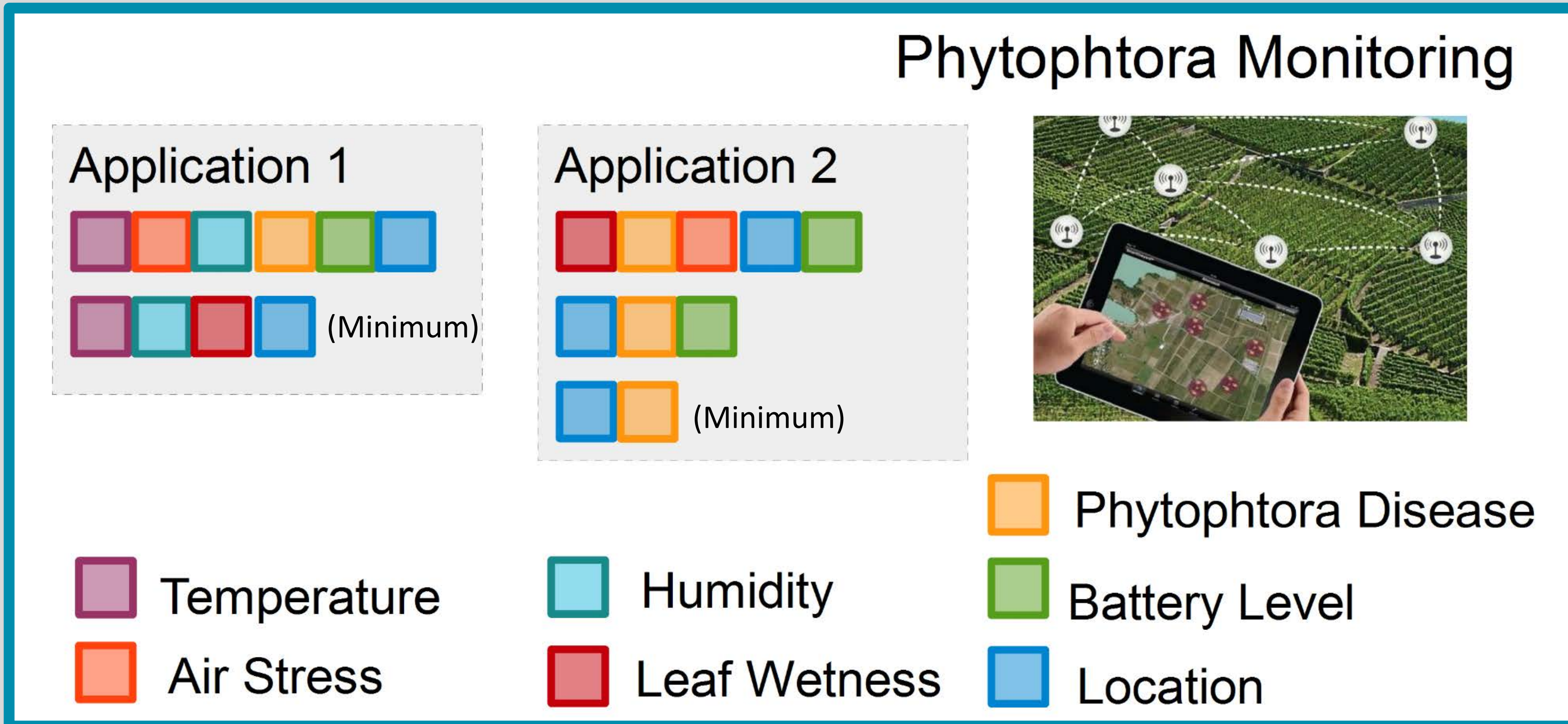
- CO Level
- CO2 Level
- Location
- NO Level
- SP Level
- Air Temerperature

Indoor Crowd Movement Monitoring

- RFID Reader
- Camera
- Pressure Sensors

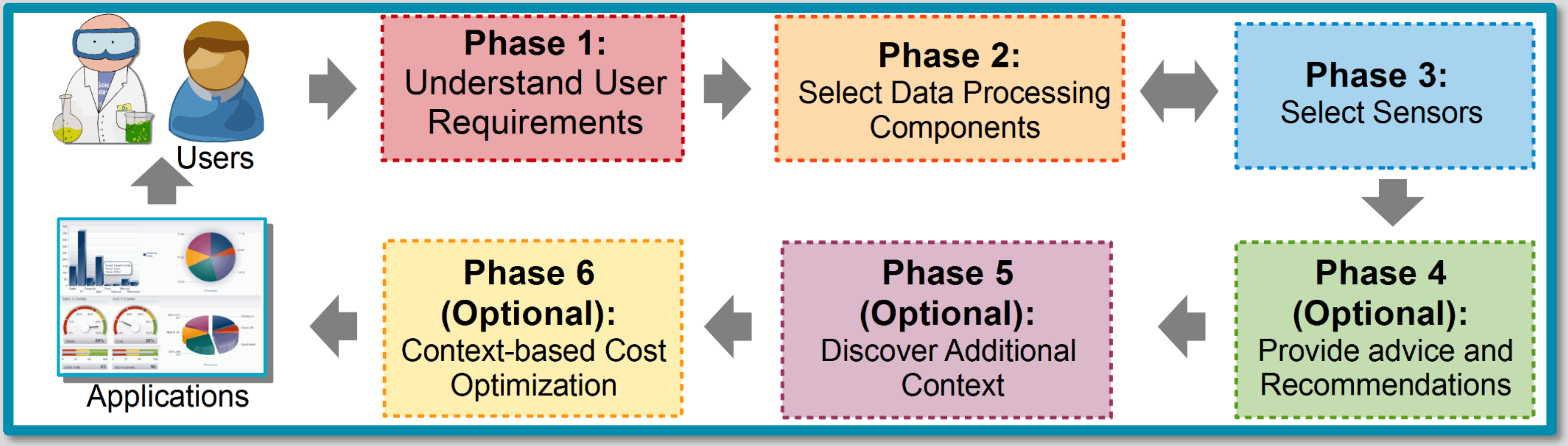
- **There are many applications that can perform a given task**
- **The required data input varies from one application to another**

Objectives and Assumptions



- **Each application may support different data inputs**
- **More data -> More functionalities**

Proposed Solutions: CASCOM

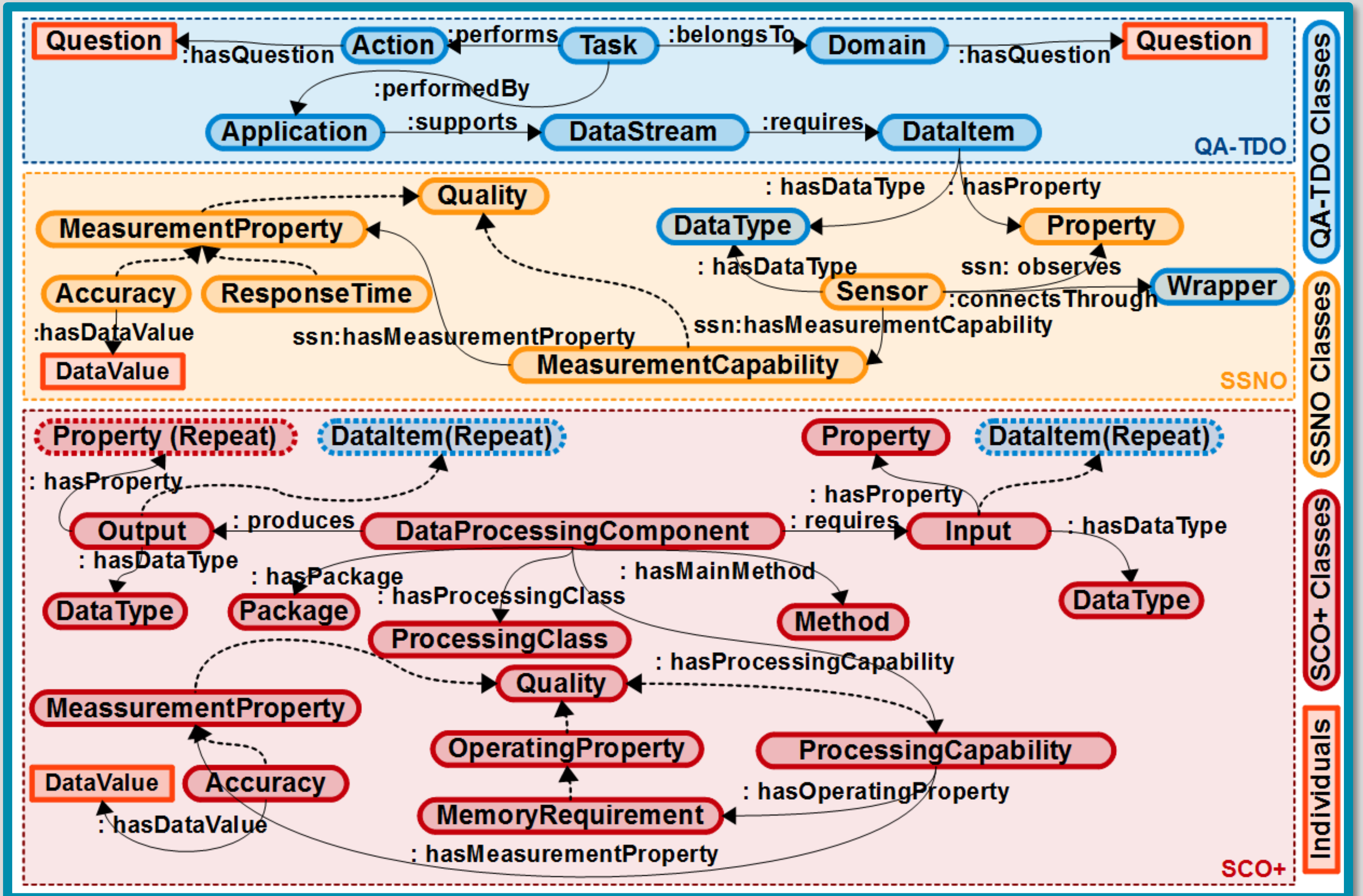


- **Orchestrate IoT resources:**
  Sensors and Data processing components

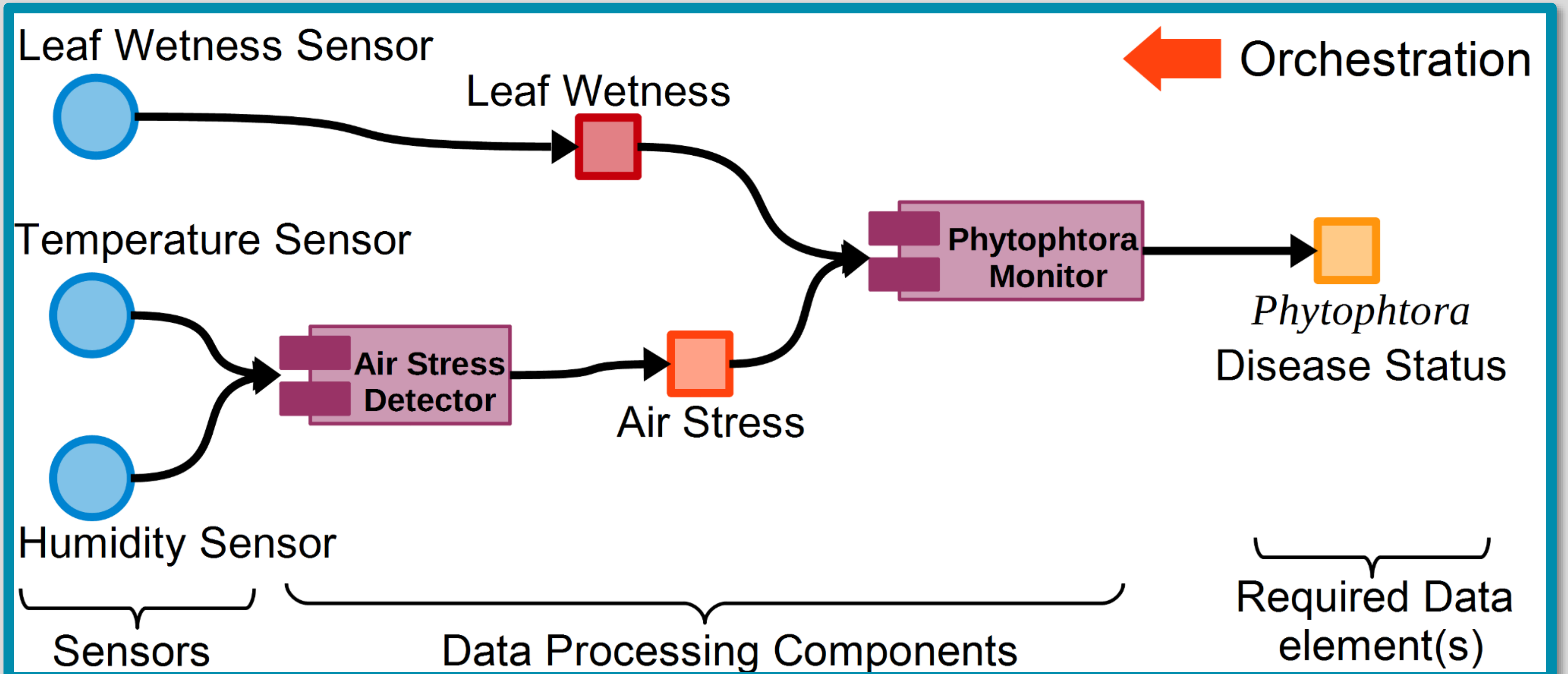
Phase 6:

Charith Perera, Arkady Zaslavsky, Chi Harold Liu, Michael Compton, Peter Christen, and Dimitrios Georgakopoulos, Sensor Search Techniques for Sensing as a Service Architecture for The Internet of Things, ***IEEE Sensors Journal***, Volume xx, Issue x, 2014

Charith Perera, Arkady Zaslavsky, Peter Christen, Michael Compton, and Dimitrios Georgakopoulos, Context-aware Sensor Search, Selection and Ranking Model for Internet of Things Middleware, Proceedings of the **IEEE 14th International Conference on Mobile Data Management (MDM)**, Milan, Italy, June, 2013

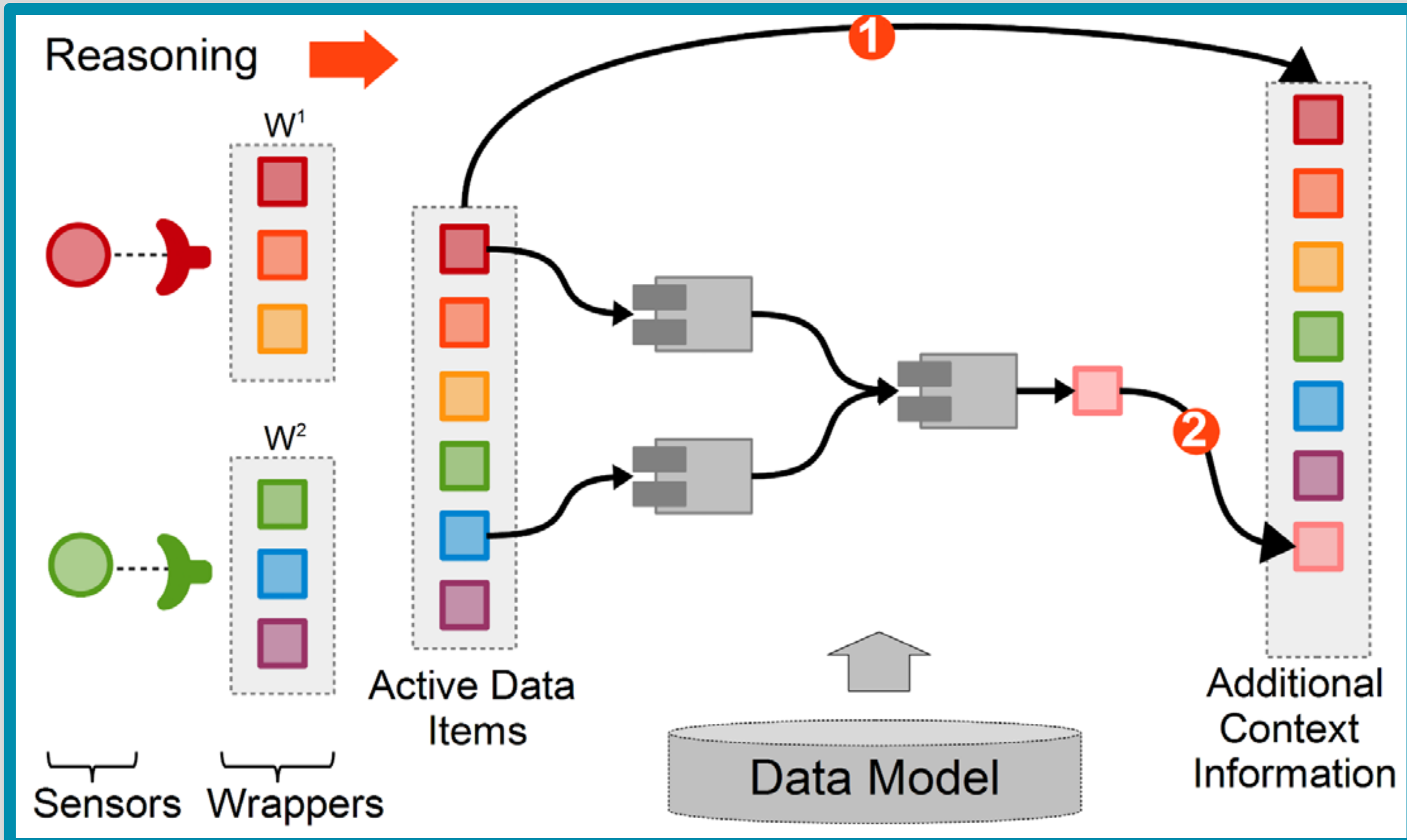

Question
:hasQuestion
Action
:performs
Task
:belongsTo
Domain
:hasQuestion
Question
:performedBy
Application
:supports
DataStream
:requires
DataItem
QA-TDO
Quality
MeasurementProperty
: hasDataType
: hasProperty
DataType
Property
Accuracy
ResponseTime
: hasDataType
ssn: observes
Sensor
Wrapper
:connectsThrough
:hasDataValue
ssn:hasMeasurementProperty
ssn:hasMeasurementCapability
DataValue
MeasurementCapability
SSNO
Property (Repeat)
DataItem(Repeat)
Property
DataItem(Repeat)
: hasProperty
: hasProperty
: produces
Output
DataProcessingComponent
: requires
Input
: hasDataType
: hasDataType
: hasPackage
: hasMainMethod
: hasProcessingClass
DataType
Package
Method
DataType
ProcessingClass
: hasProcessingCapability
Quality
MeassurementProperty
OperatingProperty
ProcessingCapability
DataValue
Accuracy
: hasOperatingProperty
: hasDataValue
MemoryRequirement
: hasMeasurementProperty
SCO+
QA-TDO Classes
SSNO Classes
SCO+ Classes
Individuals

IoT Resource Orchestration



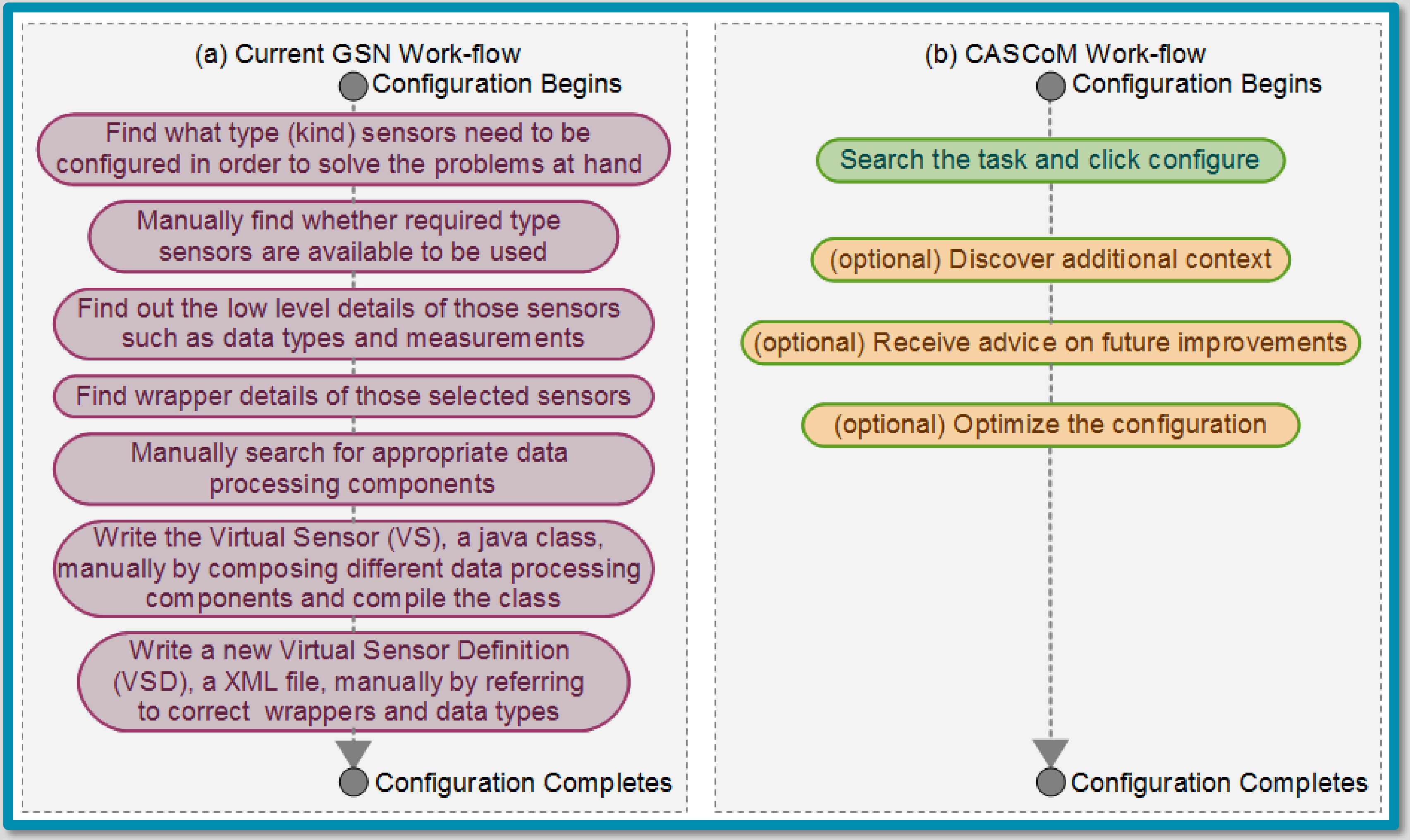
- **Step 1: Identify the data items required**
- **Step 2: Iteratively find the sensors and data processing components that can produces such data items.**

Discover Additional Context



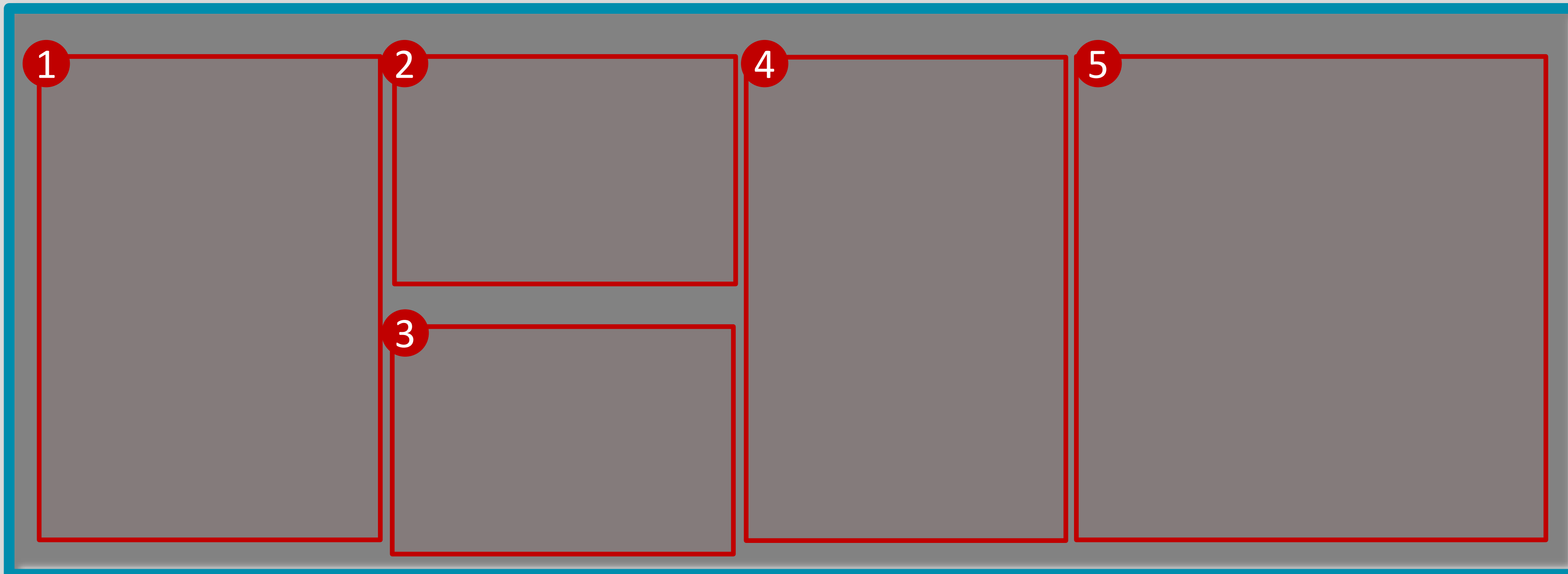
- **Current battery level -> Reaming battery / Time remaining**
  Energy efficient sensing

Advantage



(a) Current GSN Work-flow
Configuration Begins
Find what type (kind) sensors need to be configured in order to solve the problems at hand
Manually find whether required type sensors are available to be used
Find out the low level details of those sensors such as data types and measurements
Find wrapper details of those selected sensors
Manually search for appropriate data processing components
Write the Virtual Sensor (VS), a java class, manually by composing different data processing components and compile the class
Write a new Virtual Sensor Definition (VSD), a XML file, manually by referring to correct wrappers and data types
Configuration Completes
(b) CASCoM Work-flow
Configuration Begins
Search the task and click configure
(optional) Discover additional context
(optional) Receive advice on future improvements
(optional) Optimize the configuration
Configuration Completes

Implementation



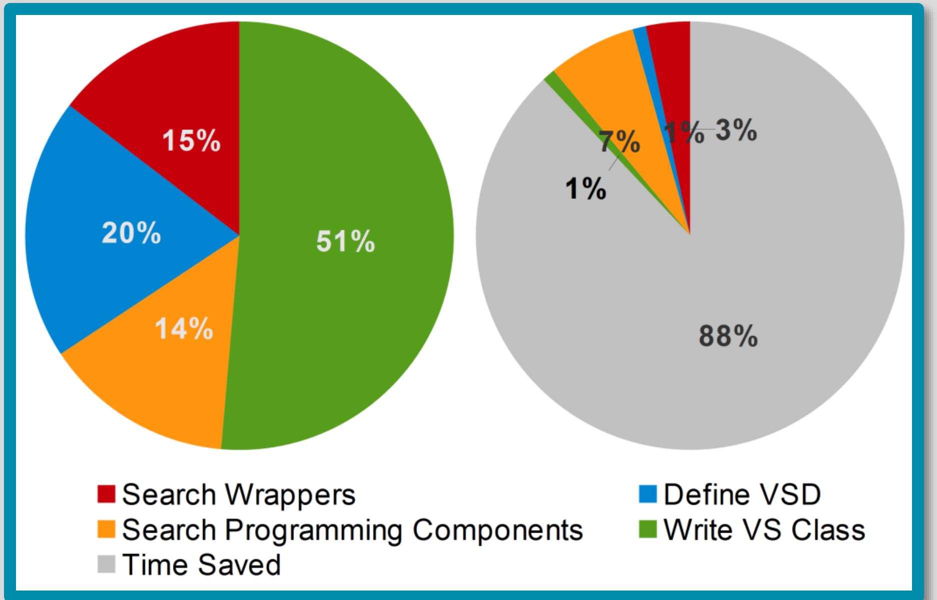
Users can select questions from 1 and search for answers. Then users needs to select an answer from 2. Related tasks are automatically listed in 3. More filtering can be done by answering more questions. Once select a task, system will automatically orchestrate different solutions and listed in 4 . Relevant cost factors will be listed in 5.

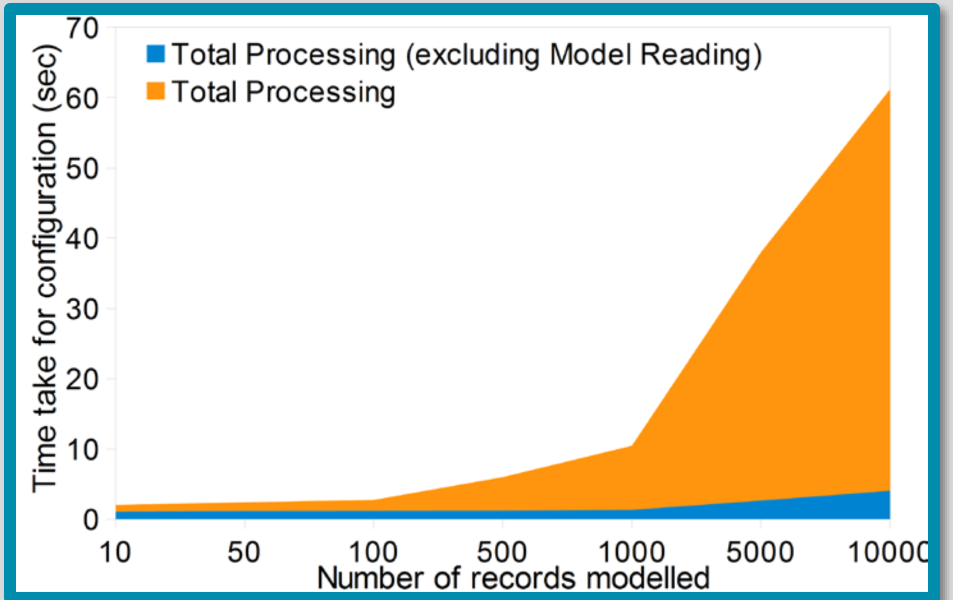
Experimentation and Evaluation

- **Users required to configure the IoT middleware in such a way that it produces a specific data stream:**
  - **(1) Monitor *Phytophtora* disease**
  - **(2) Monitor environmental pollution**
  - **(3) Monitor and analyse crowd movement (indoor)**

- **3 Types of users:**
  - **(1) A GSN expert**
  - **(2) An IT expert**
  - **(3) A non-IT expert**
- **Measurements:**
  - **(1) The amount of time taken by easy step**
  - **(2) Performance when data model increases**

Results





- **A GSN expert, an IT expert, and a non-IT expert completed the given tasks 50x, 80x and 250x times faster**
- **The GSN expert saved 88% time by using CASCoM**
- **Time taken for IoT resource orchestration is less than 4 seconds**

Conclusion and Future Work

- **Scalable: no algorithmic changes required**
- **Extendable: add sensor and component descriptions**
- **Performance: less than 4 seconds for 10,000 (x4) descriptions**
- **Simplicity and ease of use: support non-technical personal**

Future Work

- **Tools to support easy description generation**
- **Automated description generation**
- **Utility-based sensing / Pay-as-you-go**

Thank You!

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