Smart is a matter of context

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Summary

Smart cities

Why context matter?

Context and complexity

Why managing context in smart city is a machine learning challenge?

Multi agent-systems

A tool to handle complex context?

Smart cities

- Instrumented
  - Pervasive data-acquisition systems
- Interconnected
  - Data used across differents services
- Intelligent
  - Ability to analyse data
  - Efficient use of data

Smart city features relies on good context management

Smart cities

Why context matter?

Smart cities : traffic control

- Avoid traffic congestion
  - Automatic control of traffic light
- Sensors measuring number of cars
- Other contextual data to take into account
  - Weather
  - Price of fuel
  - Time of day
  - …
- Rich context. Many data. Which one is relevant?

Smart cities : smart grids

- Energy flow no more unidirectional
  - Users can produce energy
- Energy sources are intermittent
  - Wind turbine, solar panel, tidal power station, etc…
  - Thermal power stations must complete production
- Forecasting implies a good context management
  - Ability to analyse data
  - Efficient use of data

Smart cities : anomaly detection

- Buildings are using a large array of sensors
  - Motion detector, video camera, thermometer...
- Allow to detect anomalies
  - Sensor failure, degradation, strange user behaviour
- A step toward predictive maintenance
  - Improve time reaction
  - Optimizes energy consumption
- Anomalies are fundamentally contextual
  - In some context, some data could characterize normal behaviour
  - In another context, some could data characterize an anomaly

Context and complexity

Why managing context in smart city is a machine learning challenge?

Complex systems : non-linearity

When a **small change** on the input of a system may result in a **big change** on its output, the system is said **non-linear**.

- Non-linear systems are difficult to control
- Many smart-city systems are non-linear
  - Smart grids
  - Traffic
  - Heating
  - …
- Machine learning algorithms and control systems need to be sophisticated to handle non-linearity

Complex systems : openness

A system is said **open** when parts may dynamically **enter** and **exit** the system.

- New devices are added
  - New features
  - Replacement of old sensors
- Old devices are removed
  - Broken devices
  - Obsolete features
- Difficult problem for many machine learning algorithms
  - Like neural network and evolutionary algorithms

Complex systems : large-scale

The **large amount of data** available to smart cities makes it necessary to think of the problems on a **large scale**.

- Huge production of data
  - Many sensors
  - Fast Sampling Frequency
  - Users provide data (mobile devices)
- Huge flow of data
  - Many services need data
  - Critical systems need data as soon as possible
- Centralized management of data risks to be overrun

Complex systems : heterogeneity

Contextual data in smart cities include a large variety of data types, whether they are **numerical** or not, **continuous** or **discrete**, **multidimensional** or not.

- Algorithms are good at handling numerical data
- Handling numerical data and abstract concepts together is harder
  - Color, emotion, smell...
- Heterogeneity in time scales
  - Measurement every second / month / year
  - Algorithms usually suited for a given timescale

Complex systems : unpredictable dynamics

As a consequence of the other properties of complex systems, the **dynamics** of smart cities are **hardly predictable**, or even **unpredictable**.

- Several factors affect this problem
  - Non-linearity
  - Partial perception
  - Unreliable data
  - ...
- Makes it difficult for artificial learning algorithms
  - Need to perpetually self-adapt
  - Offline learning is unsuited to this type of problem

Multi agent-systems

A tool to handle complex context?

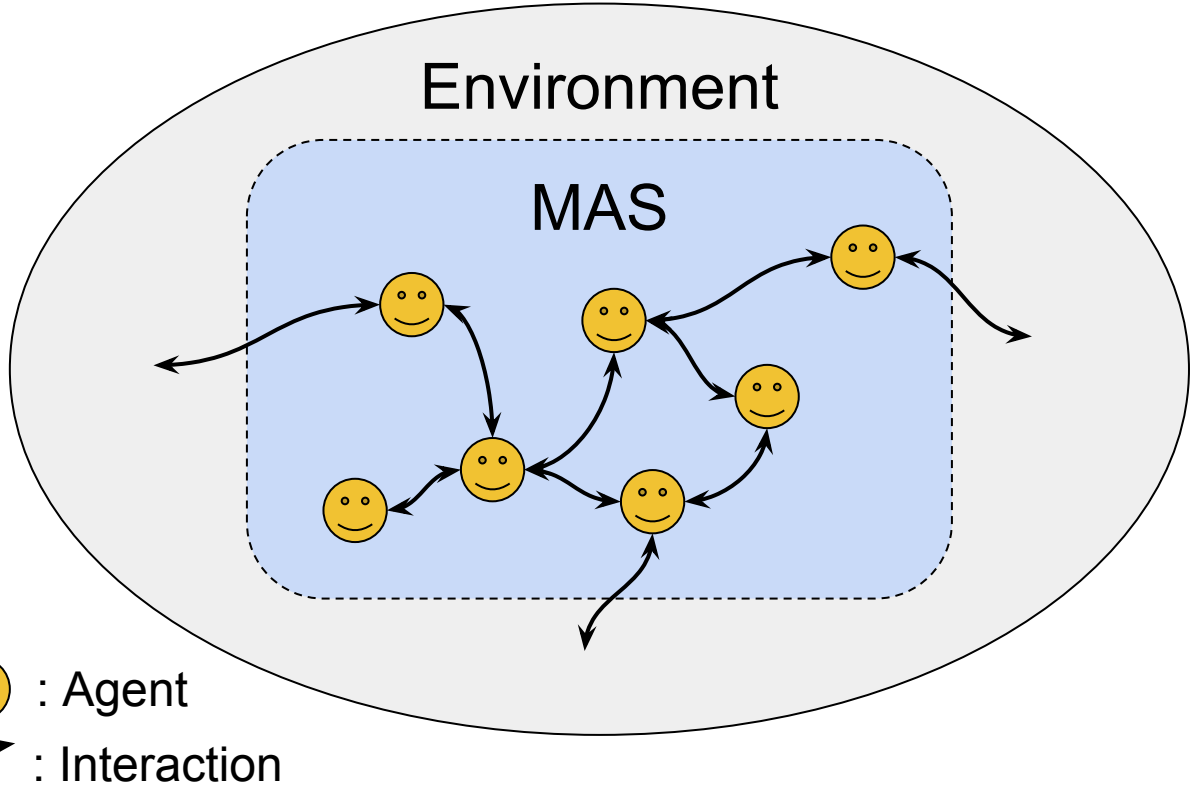
How to handle complex systems?

- To deal with smart city context, we need to handle complexity
- From our field, multi-agent systems (MAS) present interesting properties

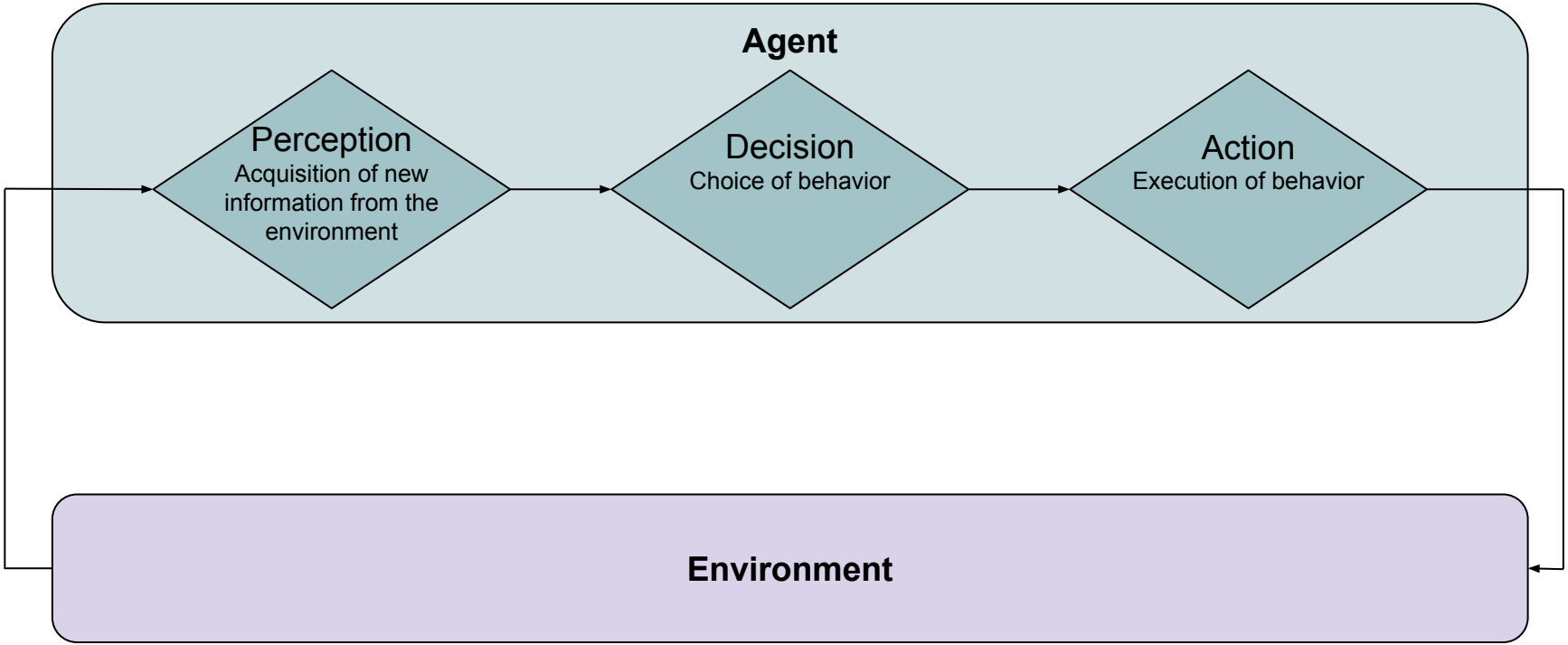
Now, we briefly present MAS, and why this kind of paradigm is interesting to handle complexity.

Multi-agent paradigm

- A set of agents
  - autonomous
  - in interaction
  - with local perceptions
- An environment



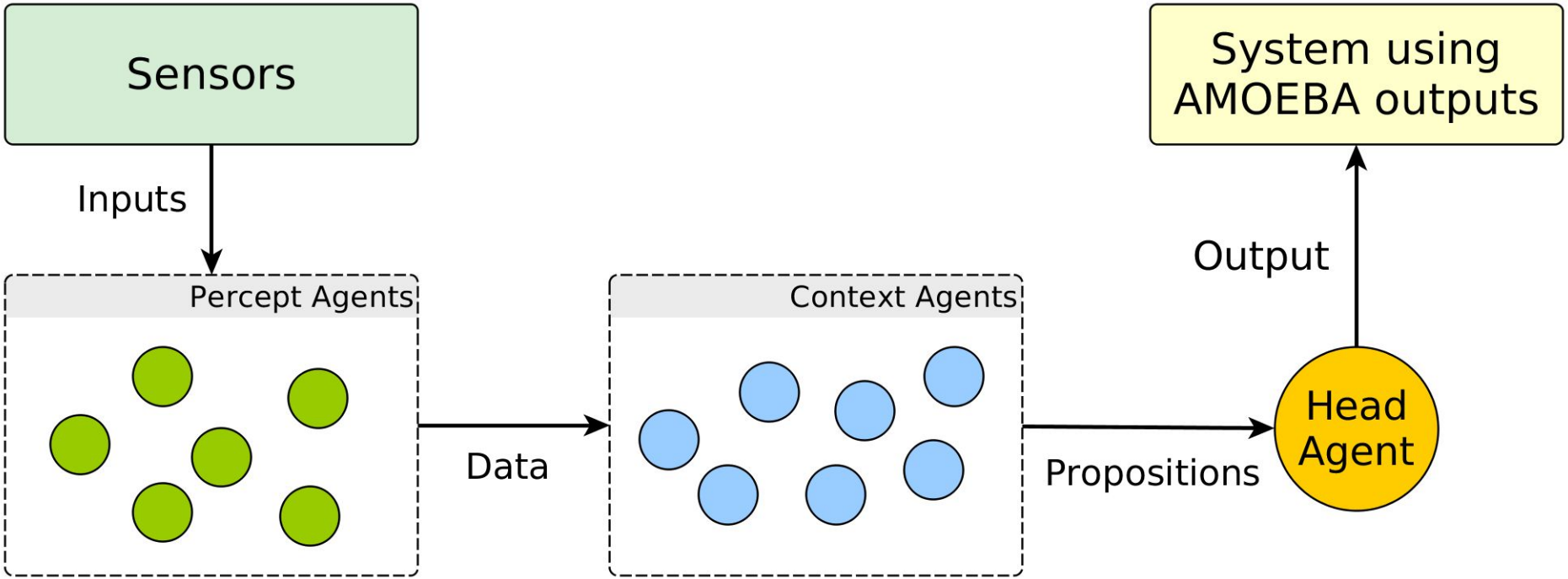
Multi-agent lifecycle



Multi-agent properties addressing complexity

- Bottom-up design
  - Focusing on the entities and their interactions at a local level
- Distributed control
  - No preset hierarchical organisation
- Adaptive
  - Change interactions
  - Add or remove new agents
- Self-*
  - Agents designed to be themselves autonomous

AMOEBA : contextual model builder

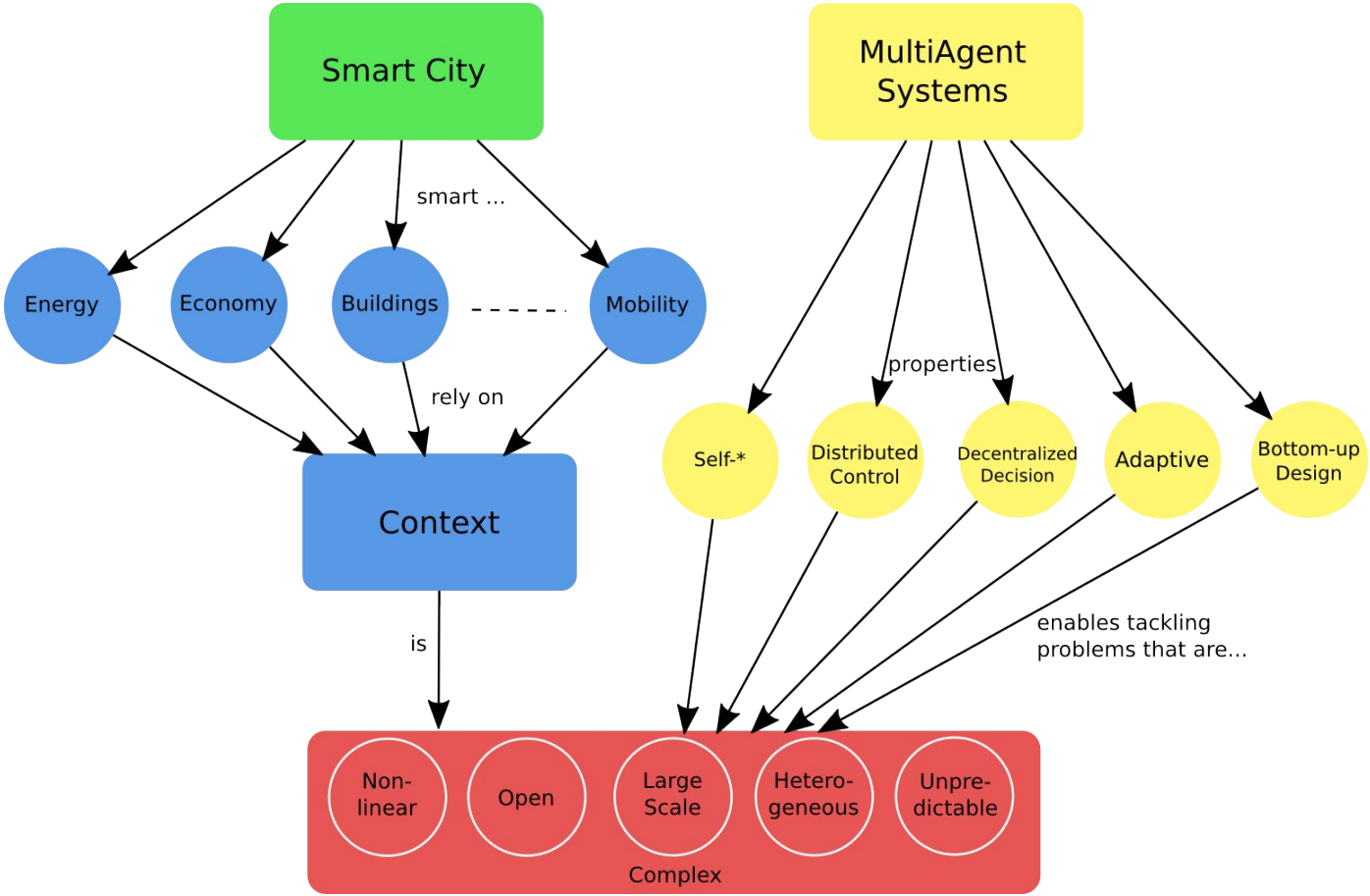


Nigon, J., Gleizes, M. P., & Migeon, F. (2016). Self-adaptive model generation for ambient systems. Procedia Computer Science, 83, b675-679.

Conclusion

- Managing a smart city is all about managing rich context
- Smart city is a complex system
- Complex systems features make machine learning and control difficult
  - Non-linearity, heterogeneity, large scale…
- Algorithms must show specific properties to handle complex context
  - Distributed, self-*, adaptivity
- From our field, MAS presents these properties
  - We work on a contextual machine learning algorithm : AMOEBA

Graphical conclusion



Thank you for your attention.