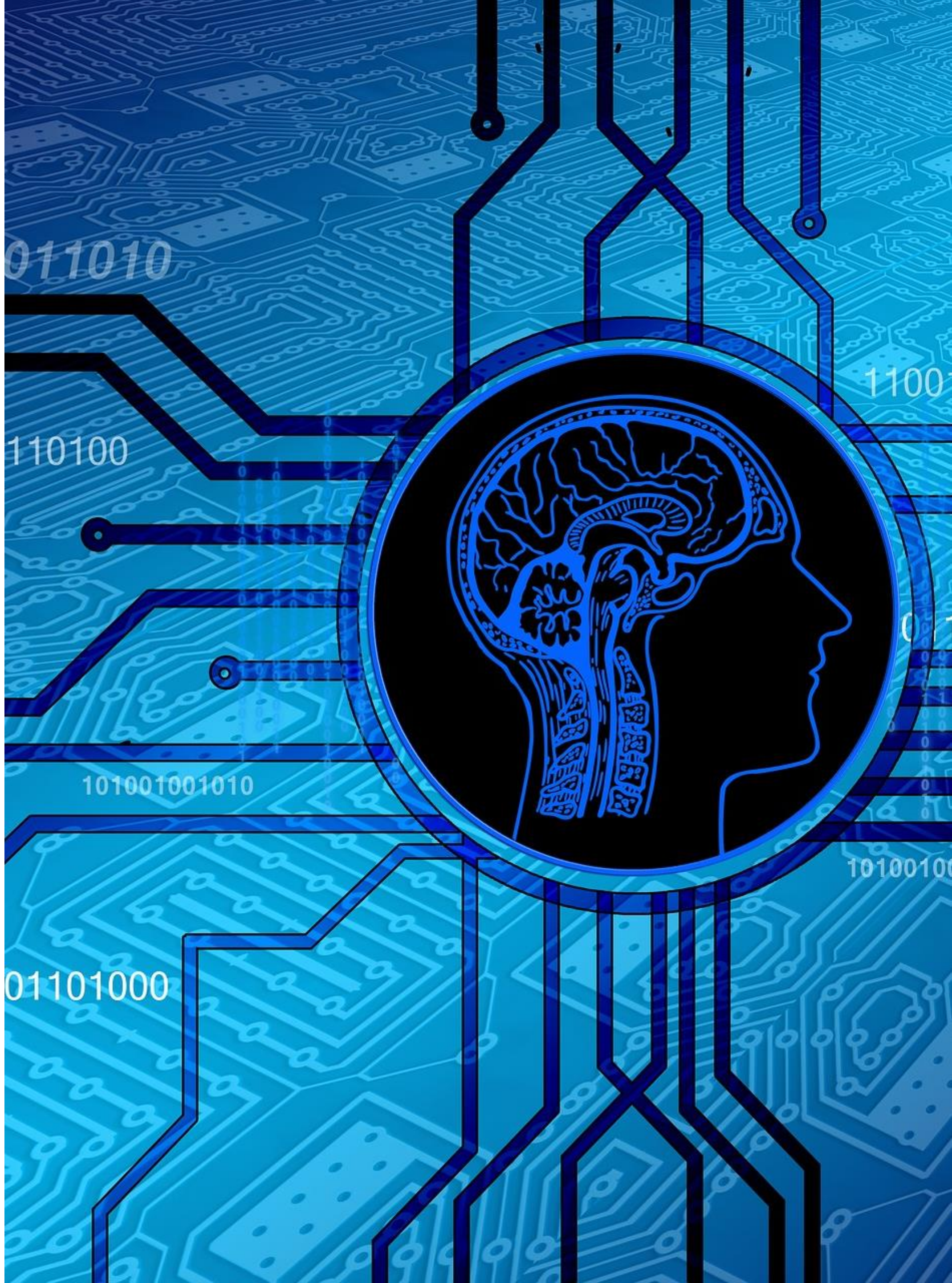
Intelligent Agents and their Environments

Informatics 2D: Reasoning and Agents

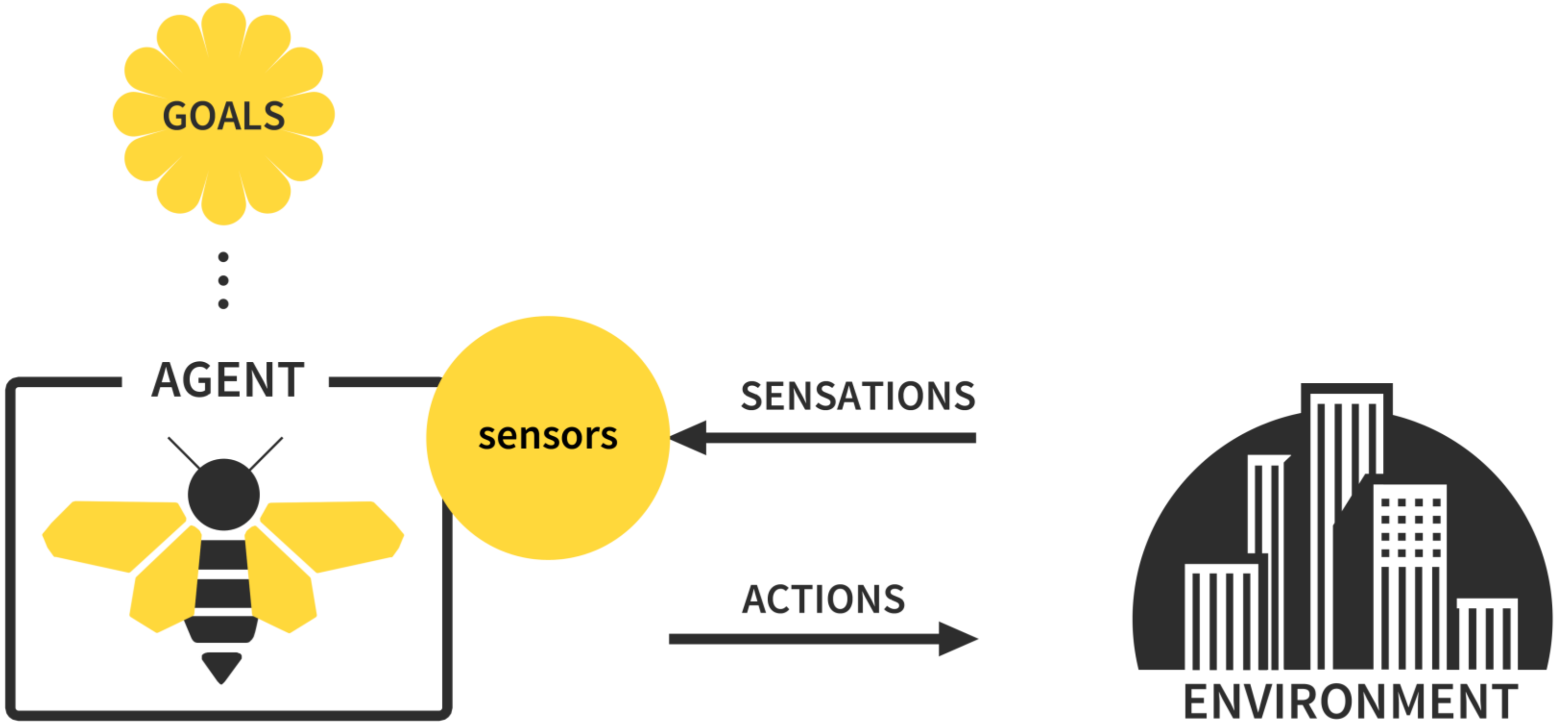
Lecture 1

Adapted from slides provided by Dr Petros Papapanagiotou

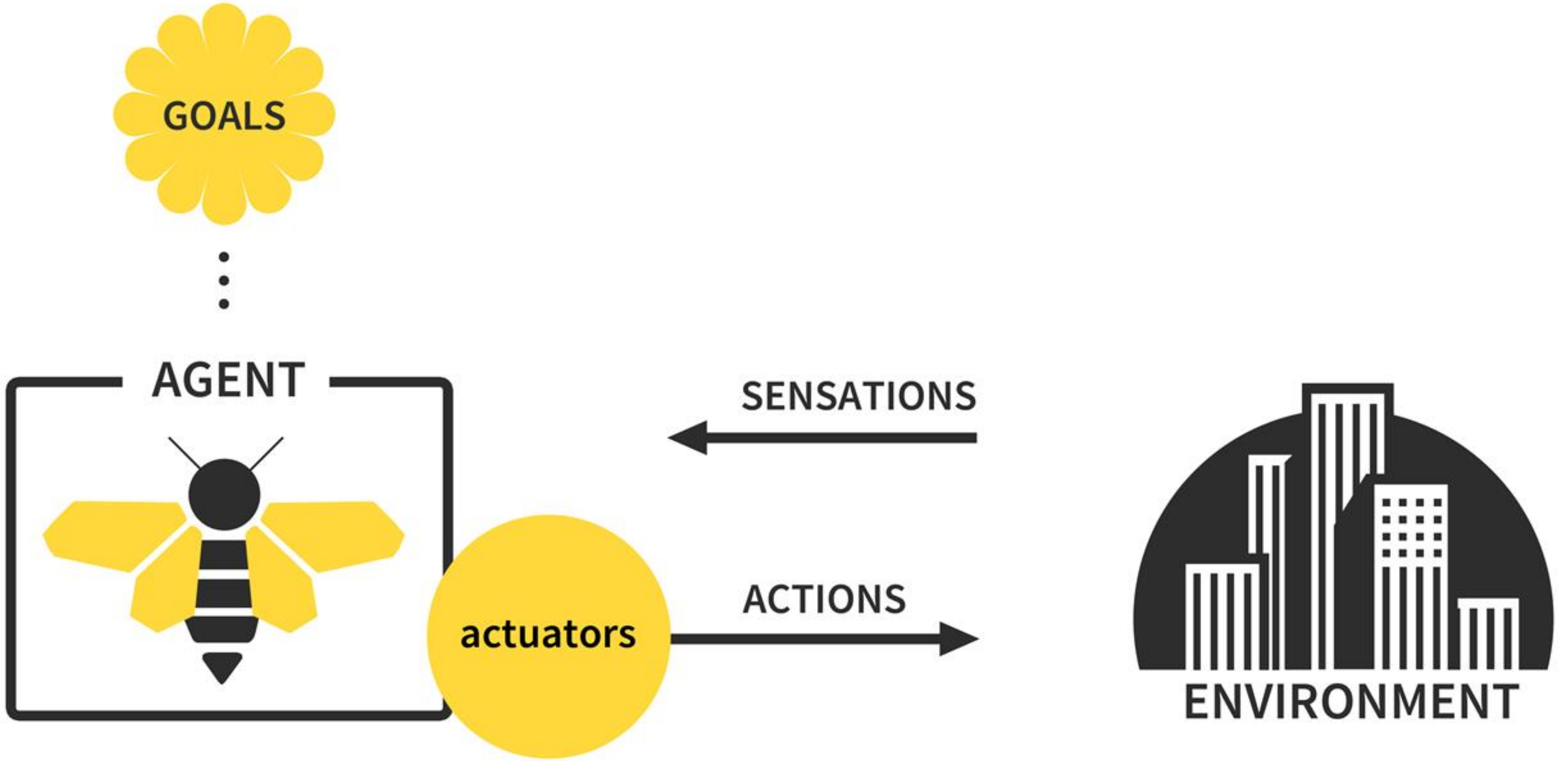


What is an Intelligent Agent?

Structure



Structure



An agent

Perceives its *environment*,

Through its *sensors*,

Then achieves its *goals*,

By acting on its environment via *actuators*.

Categorise agents

- Environment
- Goals
- Percepts
- Actions

Example: Mail sorting

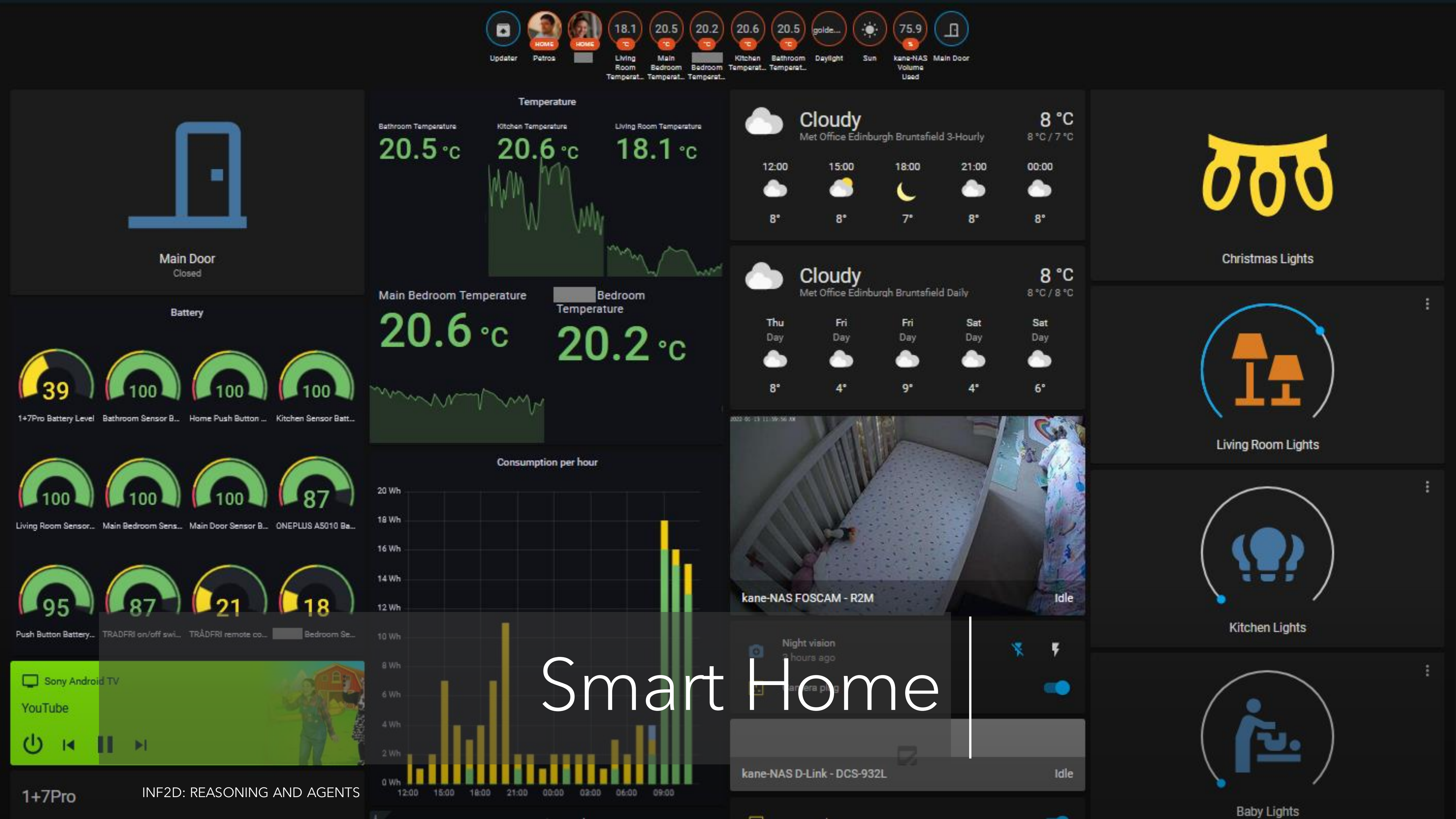
Conveyor belt of letters

Route letter into correct bin

Array of pixel intensities

Route letter into bin

Smart Home



Updater
Petros
HOME
HOME
[redacted]
18.1 °C Living Room Temperat...
20.5 °C Main Bedroom Temperat...
20.2 °C [redacted] Bedroom Temperat...
20.6 °C Kitchen Temperat...
20.5 °C Bathroom Temperat...
golde... Daylight
Sun
75.9 % kane-NAS Volume Used
Main Door
Main Door
Closed
Temperature
Bathroom Temperature 20.5 °C
Kitchen Temperature 20.6 °C
Living Room Temperature 18.1 °C
Main Bedroom Temperature 20.6 °C
[redacted] Bedroom Temperature 20.2 °C
Cloudy
Met Office Edinburgh Bruntsfield 3-Hourly
8 °C
8 °C / 7 °C
12:00 15:00 18:00 21:00 00:00
8° 8° 7° 8° 8°
Cloudy
Met Office Edinburgh Bruntsfield Daily
8 °C
8 °C / 8 °C
Thu Day Fri Day Fri Day Sat Day Sat Day
8° 4° 9° 4° 6°
Christmas Lights
Living Room Lights
Kitchen Lights
Baby Lights
Battery
39 1+7Pro Battery Level
100 Bathroom Sensor B...
100 Home Push Button ...
100 Kitchen Sensor Batt...
100 Living Room Sensor...
100 Main Bedroom Sens...
100 Main Door Sensor B...
87 ONEPLUS A5010 Ba...
95 Push Button Battery...
87 TRADFRI on/off swi...
21 TRÅDFRI remote co...
18 [redacted] Bedroom Se...
Consumption per hour
20 Wh 18 Wh 16 Wh 14 Wh 12 Wh 10 Wh 8 Wh 6 Wh 4 Wh 2 Wh 0 Wh
12:00 15:00 18:00 21:00 00:00 03:00 06:00 09:00
kane-NAS FOSCAM - R2M
Idle
Night vision
2 hours ago
Camera plug
kane-NAS D-Link - DCS-932L
Idle
Sony Android TV
YouTube
1+7Pro

Example: Smart home

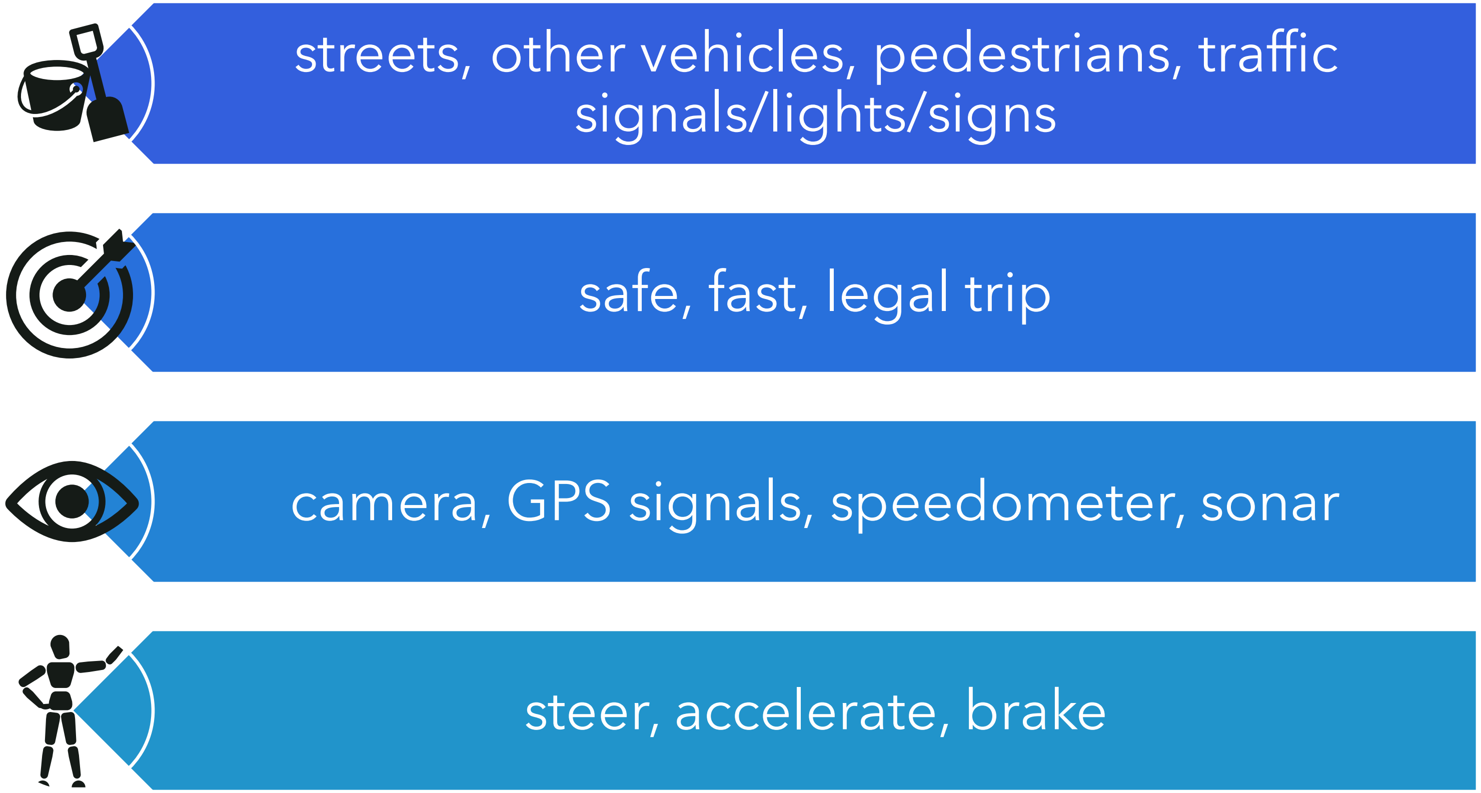
occupants enter and leave house, occupants enter and leave rooms; daily variation in outside light and temperature

occupants warm, room lights are on when room is occupied, house energy efficient

signals from temperature sensors, movement sensors, clock, sound sensor, weather sensor

room heaters on/off, lights on/off

Example: Autonomous car



streets, other vehicles, pedestrians, traffic signals/lights/signs

safe, fast, legal trip

camera, GPS signals, speedometer, sonar

steer, accelerate, brake

Type of Intelligent Agents

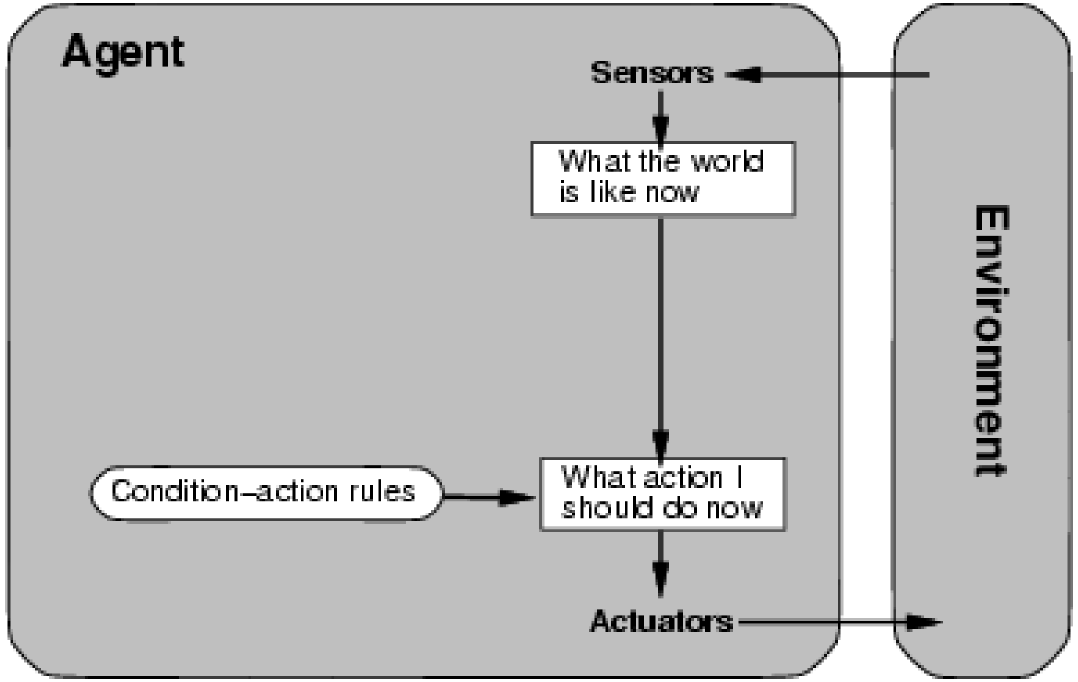
Simple Reflex Agents

Action depends only on immediate percepts.

Implement by *condition-action rules*.

Example:

- Agent: Mail sorting robot
- Environment: Conveyor belt of letters
- Rule: e.g. *city=Edinburgh* → *put in Scotland bag*



Simple Reflex Agents

```
function SIMPLE-REFLEX-AGENT(percept)
returns action
  persistent: rules (set of condition-action rules)
          state ← INTERPRET-INPUT(percept)
          rule ← RULE-MATCH(state, rules)
          action ← rule.ACTION
return action
```

Model-Based Reflex Agents

Action may depend on history or unperceived aspects of the world.

Need to maintain *internal world model*.

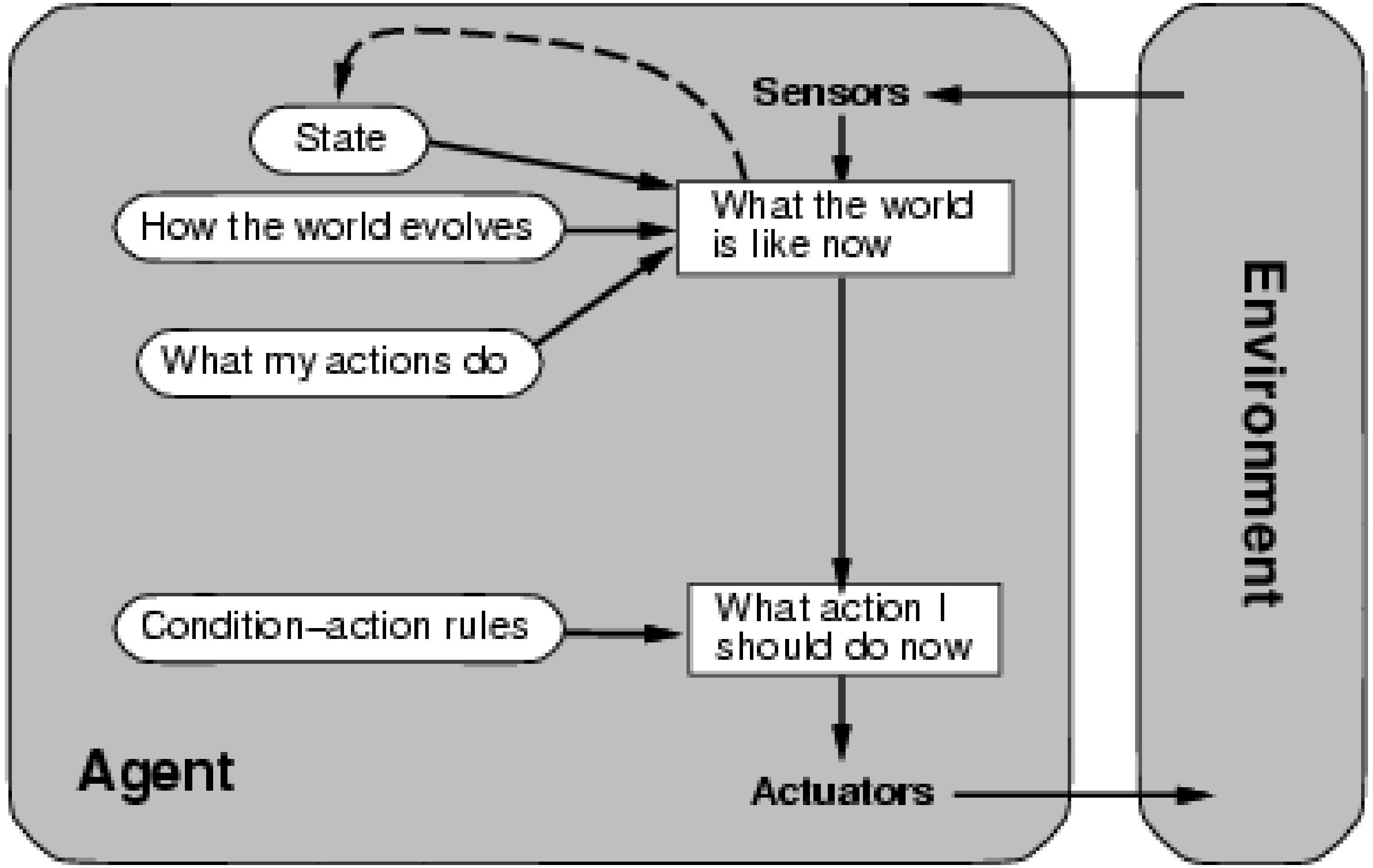
Example:

Agent: robot vacuum cleaner

Environment: dirty room, furniture

Model: map of room, which areas already cleaned

Sensor/model tradeoff.



Model-Based Reflex Agents

```
function REFLEX-AGENT-WITH-STATE(percept)
 returns action
 persistent: state, description of current world state
             model, description of how the next state
                    depends on current state and action
             rules, a set of condition-action rules
             action, the most recent action, initially none
 state ← UPDATE-STATE(state, action, percept, model)
 rule ← RULE-MATCH(state, rules)
 action ← rule.ACTION
 return action
```

Goal-Based Agents

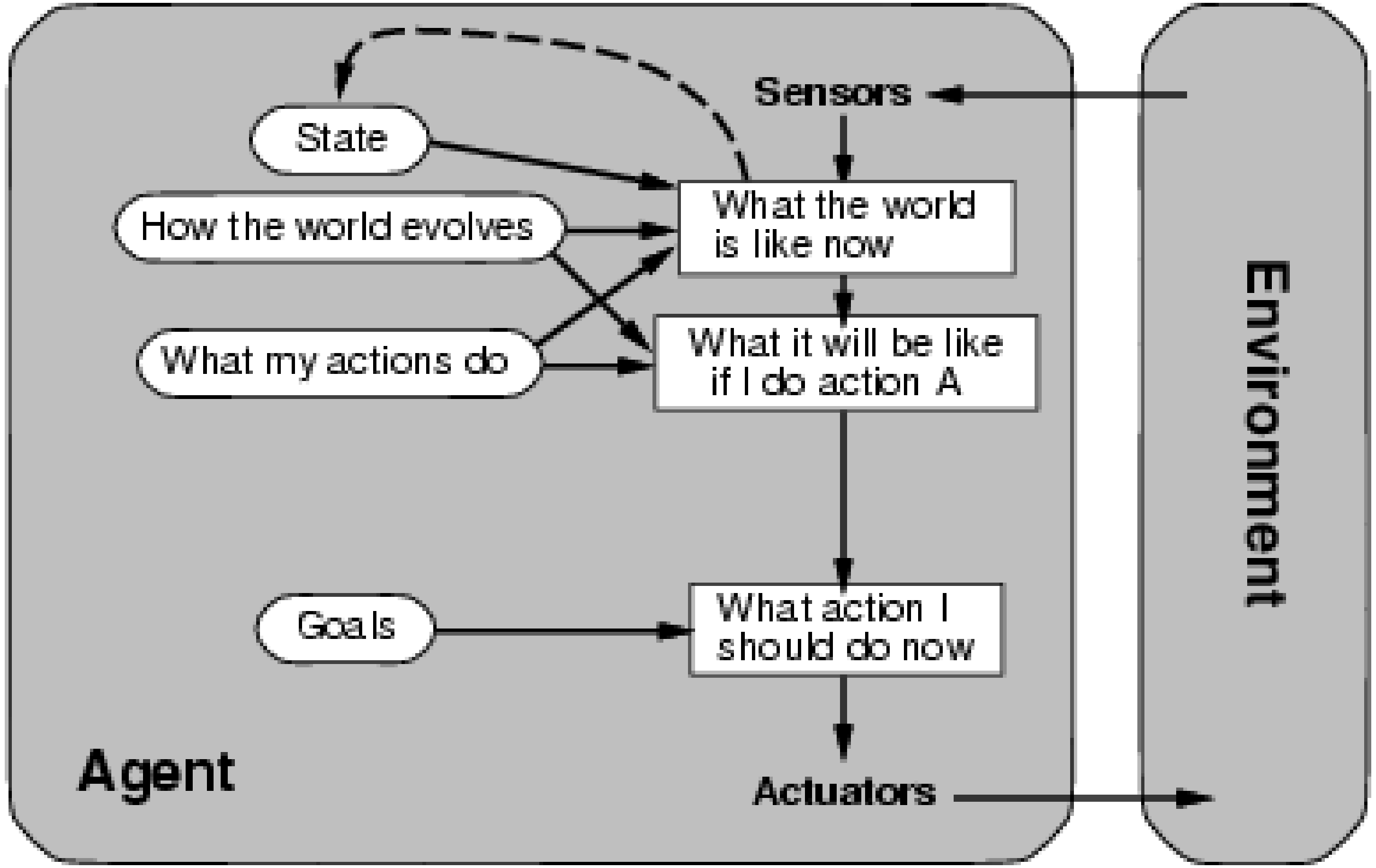
Agents so far have fixed, implicit goals.

We want agents with variable goals.

Forming plans to achieve goals is a topic for later.

Example:

- Agent: robot maid
- Environment: house & people.
- Goals: clean clothes, tidy room, table laid, etc


Sensors
State
How the world evolves
What my actions do
What the world is like now
What it will be like if I do action A
Goals
What action I should do now
Agent
Actuators
Environment

Goal-Based Agents

Utility-Based Agents

Agents so far have had a single goal.

Agents may have to juggle conflicting goals.

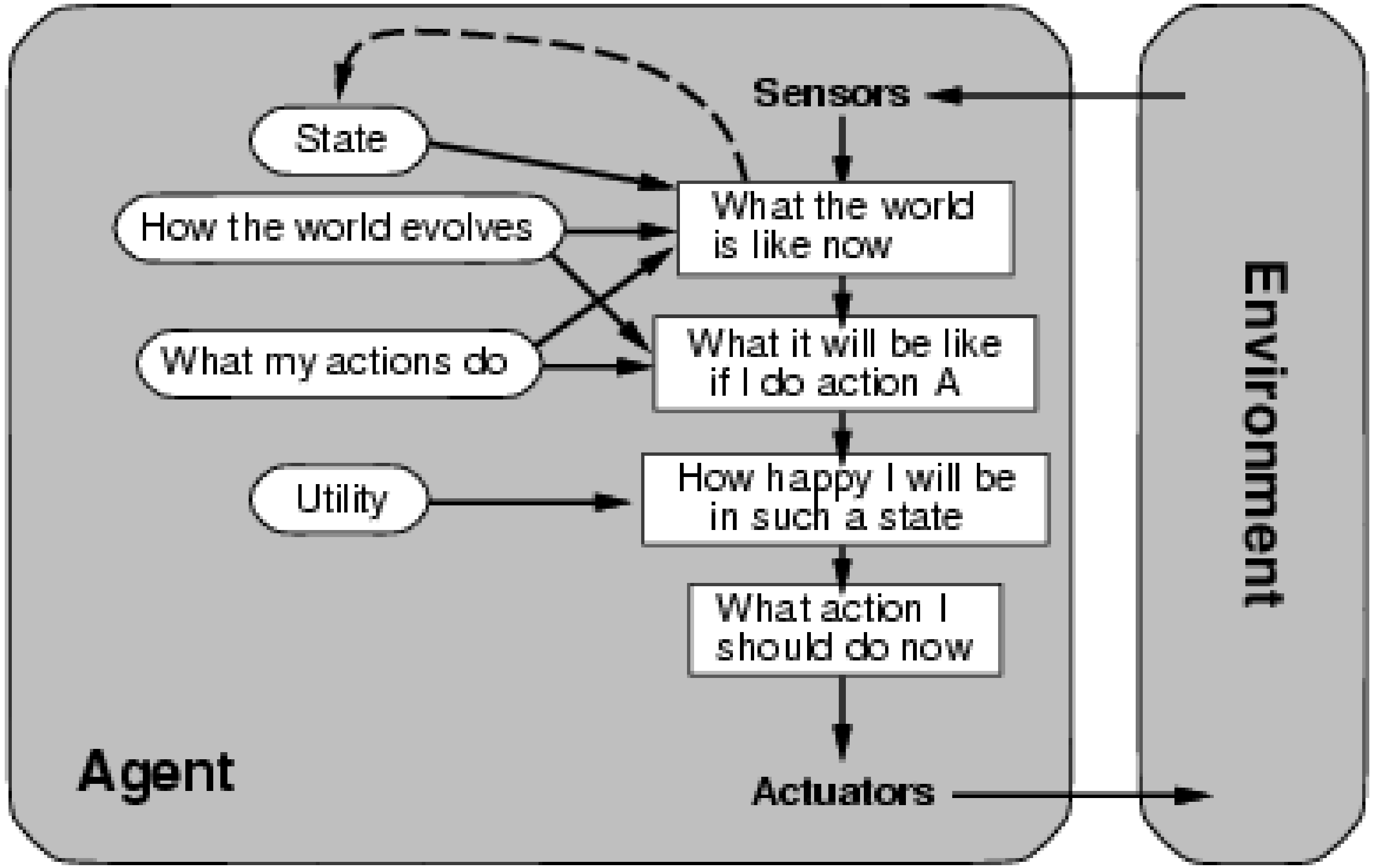
Need to optimise utility over a range of goals.

Utility: measure of *goodness* (a real number).

Combine with probability of success to get *expected utility*.

Example:

- Agent: autonomous car.
- Environment: roads, vehicles, signs, etc.
- Goals: stay safe, reach destination, be quick, obey law, save fuel, etc.


Sensors
State
What the world is like now
How the world evolves
What my actions do
What it will be like if I do action A
Utility
How happy I will be in such a state
What action I should do now
Agent
Actuators
Environment

Utility-Based Agents

Learning Agents

How do agents improve their performance in the light of experience?

- Generate problems which will test performance.
- Perform activities according to rules, goals, model, utilities, etc.
- Monitor performance and identify non-optimal activity.
- Identify and implement improvements

We will not be covering learning agents, but this topic is dealt with in several honours-level courses (see also R&N, Ch. 18-21).

Exercise

Consider a chess playing program.

What sort of agent would it need to be?

Solution

Simple-reflex agent: but some actions require some memory (e.g. castling)

Model-based reflex agent: but needs to reason about future

Goal-based agent: but only has one goal

Utility-based agent: might consider multiple goals with limited lookahead

Learning agent: learns from experience or self-play

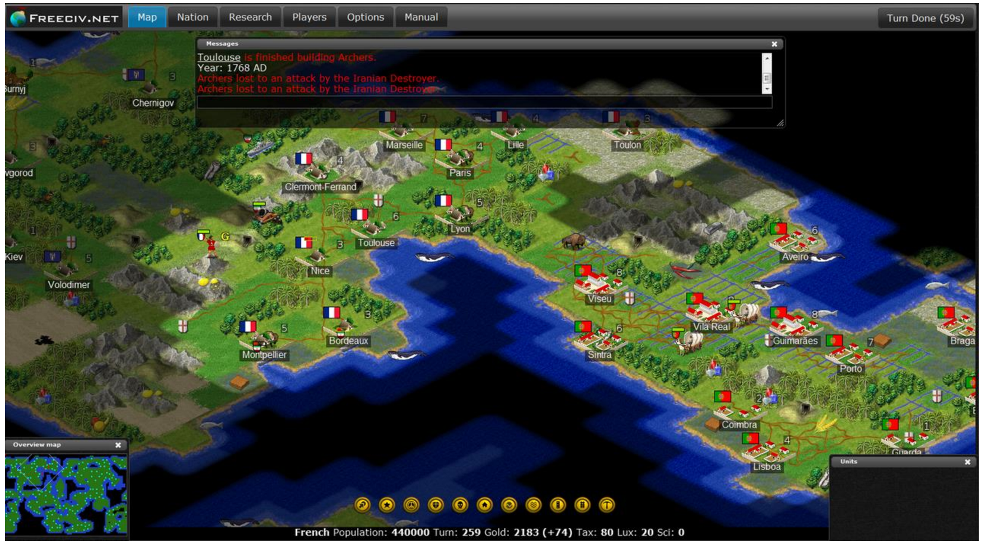
Types of Environments

Observable?

FULLY

Source

PARTIALLY



Toulouse is finished building Archers.
Year: 1768 AD
Archers lost to an attack by the Iranian Destroyer.
Archers lost to an attack by the Iranian Destroyer.

French Population: 440000 Turn: 259 Gold: 2183 (+74) Tax: 80 Lux: 20 Sci: 0

Source

Observable?

FULLY

PARTIALLY

agent's sensors describe environment fully

vs.

some parts of the environment not visible; noisy sensors

Source

Source

Deterministic?

DETERMINISTIC

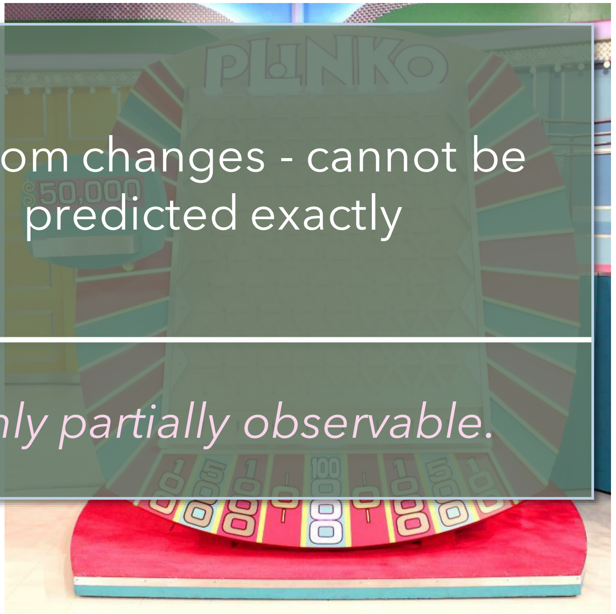
STOCHASTIC

Source

Deterministic?

DETERMINISTIC

STOCHASTIC



next state fully determined by current state and agent's actions

vs.

random changes - cannot be predicted exactly

An environment may appear stochastic if it is only partially observable.

Source

Sequential?

EPISODIC

Source

SEQUENTIAL

Sequential?

EPISODIC

SEQUENTIAL

next episode does not depend on previous actions

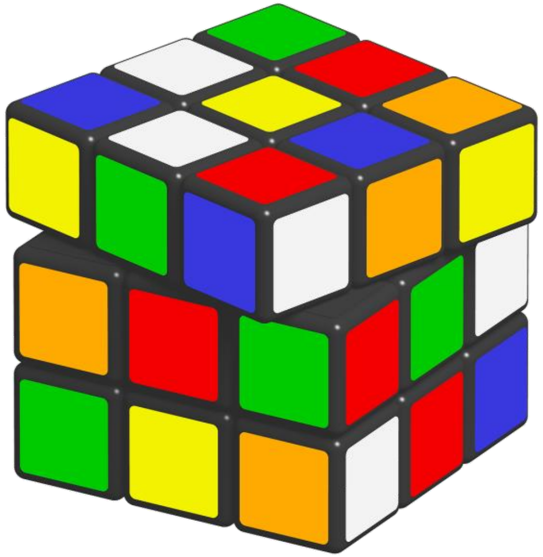
vs.

actions affect the future

Source

Static?

STATIC



DYNAMIC

Source

Static?

STATIC

DYNAMIC

Source

environment unchanged while agent deliberates ***vs.*** environment can change at any time or even continuously

Discrete?

DISCRETE

Source

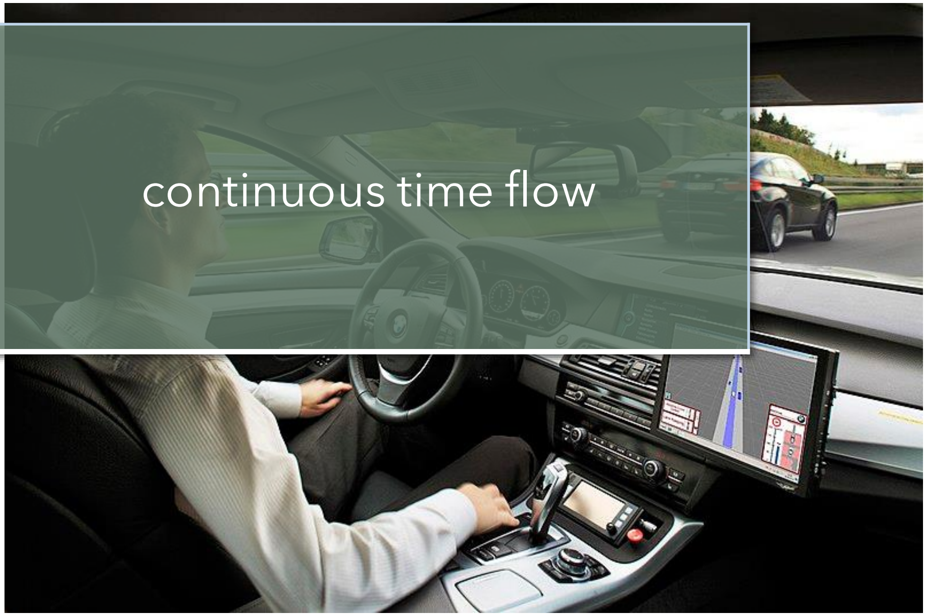
CONTINUOUS

Source

Discrete?

DISCRETE

CONTINUOUS



percepts, actions and episodes are discrete

vs.

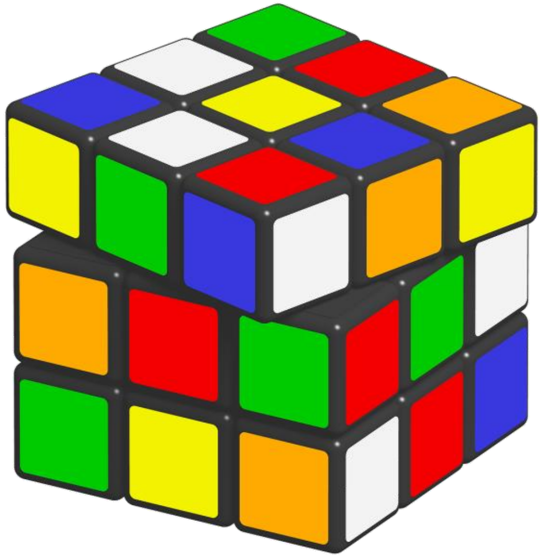
continuous time flow

Source

Source

How many agents?

SINGLE



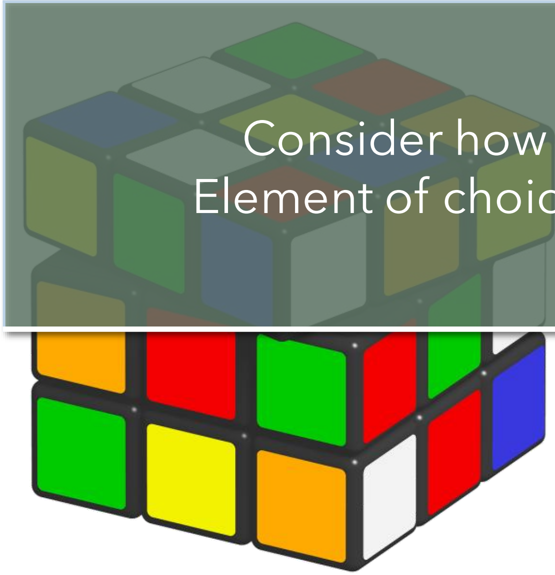
MULTI-AGENT

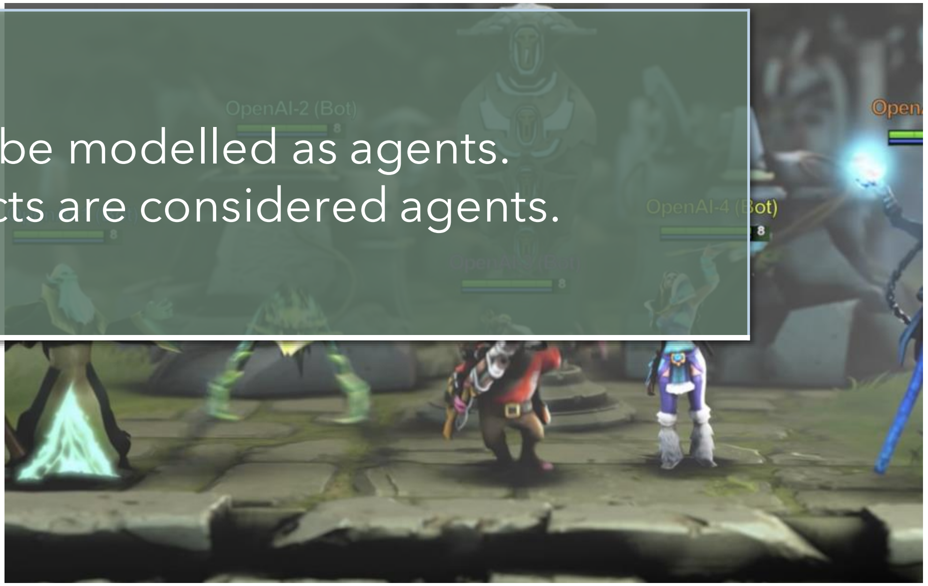
Source

How many agents?

SINGLE

MULTI-AGENT





Consider how many object must be modelled as agents.
Element of choice over which objects are considered agents.

Source

Summary

An agent might have any combination of these properties:

- from "**benign**": i.e., fully observable, deterministic, episodic, static, discrete and single agent
- to "**chaotic**": partially observable, stochastic, sequential, dynamic, continuous and multi-agent

What are the properties of the environment that would be experienced by

- a mail-sorting robot?
- a smart home?
- a car-driving robot?

Why?

- Understanding what is an agent and how it can be modelled.
- Understanding the environment and the assumptions or considerations that need to be made.
- Making the right design decisions and choosing the right tools.
- Managing the complexity.