PRIFYSGOL ABERYSTWYTH UNIVERSITY

# Intelligent Resilience in the Internet of Things

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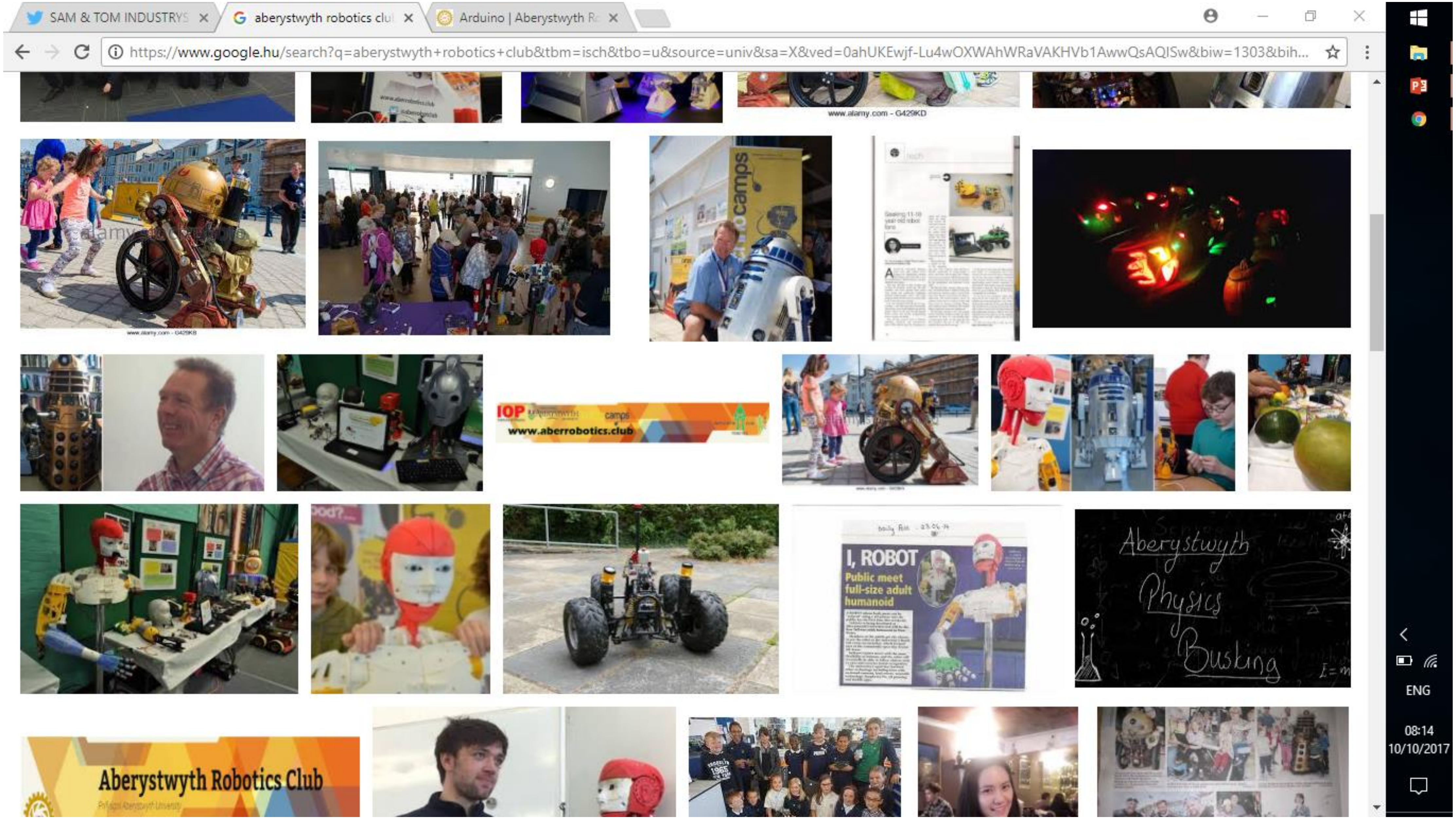
# The Challenge

- The IoT includes all manner of device, toy, safety critical element …
- The IoT is neither contained nor constrained
- Failing elements are to be expected
- So too are hostile elements
- And early prototypes …

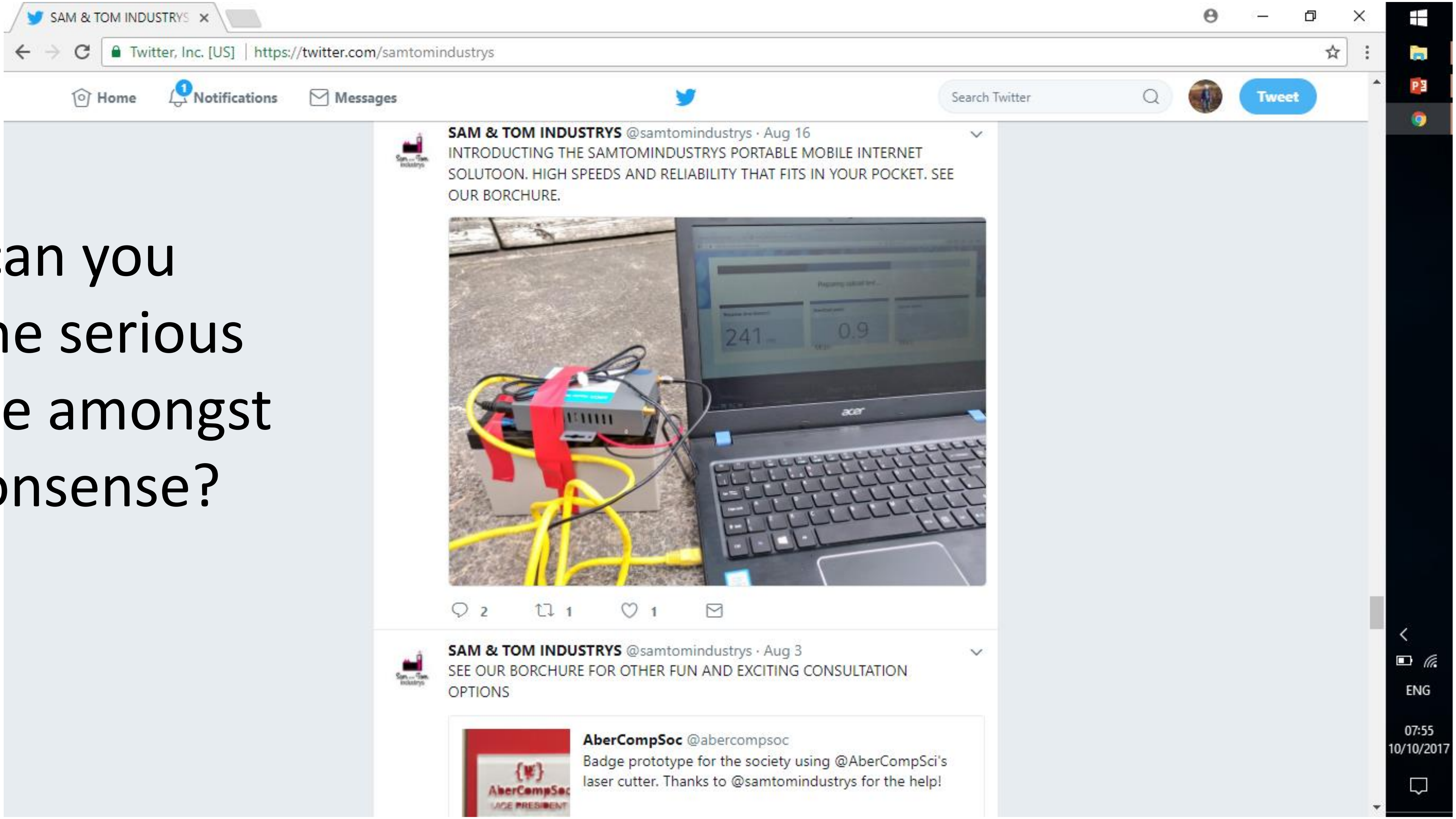
# Images of Aberystwyth Robotics Club



https://www.google.hu/search?q=aberystwyth+robotics+club&tbm=isch&tbo=u&source=univ&sa=X&ved=0ahUKEwjf-Lu4wOXWAhWRaVAKHVb1AwwQsAQISw&biw=1303&bih...

# https://twitter.com/samtomindustrys

Test: can you find the serious science amongst the nonsense?

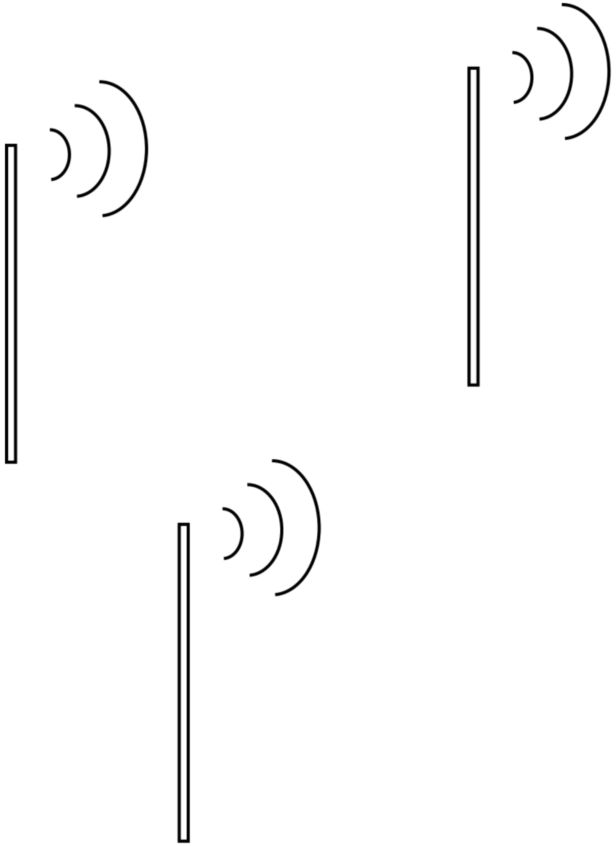


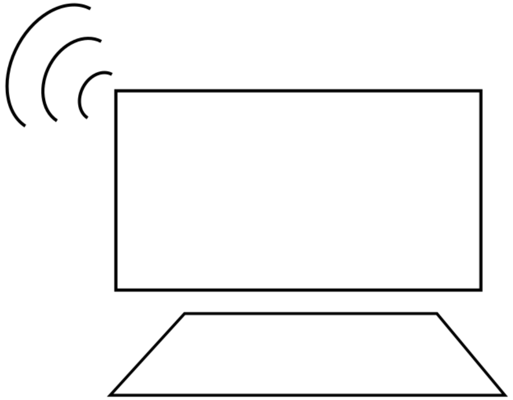
**SAM & TOM INDUSTRYS** @samtomindustrys · Aug 16
INTRODUCTING THE SAMTOMINDUSTRYS PORTABLE MOBILE INTERNET SOLUTOON. HIGH SPEEDS AND RELIABILITY THAT FITS IN YOUR POCKET. SEE OUR BORCHURE.

**SAM & TOM INDUSTRYS** @samtomindustrys · Aug 3
SEE OUR BORCHURE FOR OTHER FUN AND EXCITING CONSULTATION OPTIONS

**AberCompSoc** @abercompsoc
Badge prototype for the society using @AberCompSci's laser cutter. Thanks to @samtomindustrys for the help!

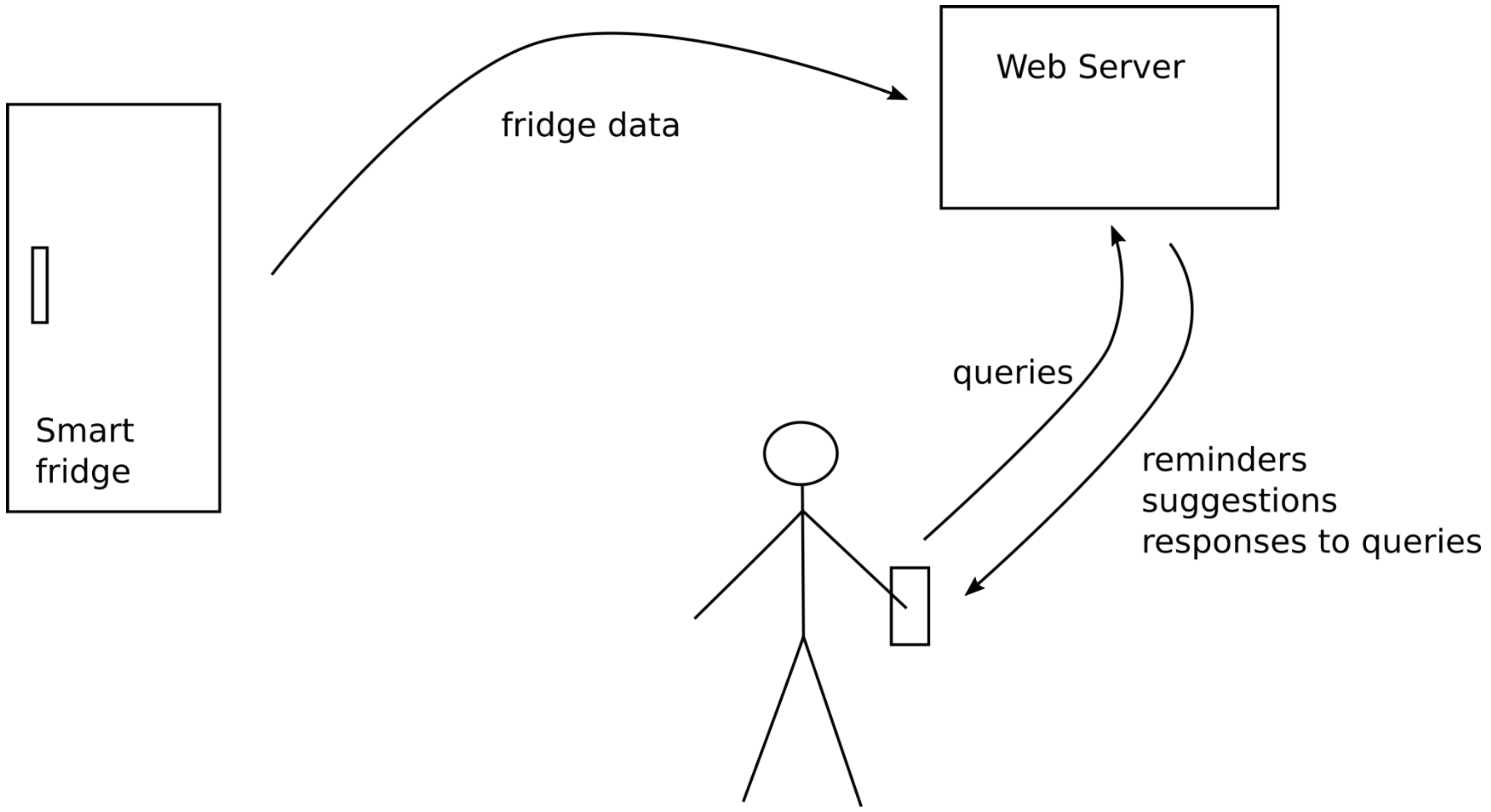
# Environmental monitoring



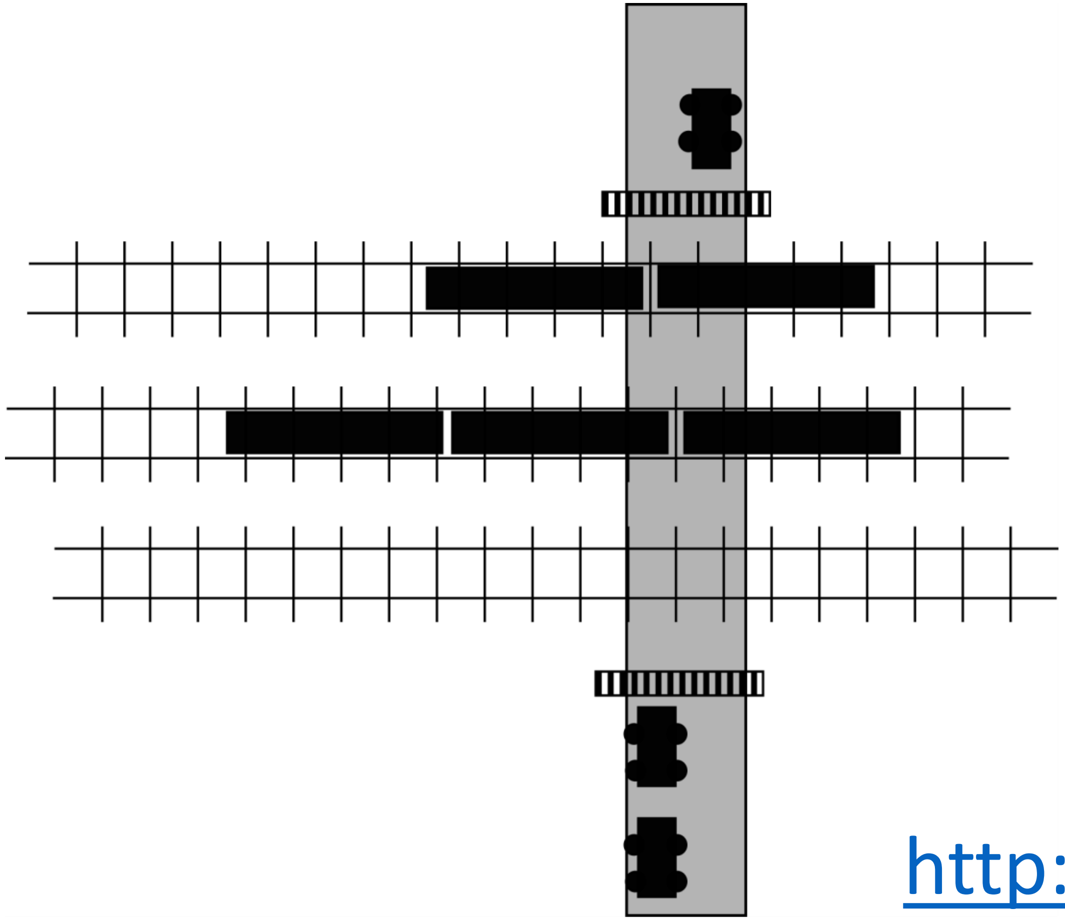


What could possibly go wrong?

# How about a smart fridge?



# Or the famous SDL challenge?



- Tracks, public highway, gates, sensors, signals controller
- Cars on the road are part of the environment

http://www.sdl-forum.org/Events/SAM03Contest.htm

# Unconstrained environments

- Area of ongoing research in robotics
- and computer vision
- and intrusion detection

The IoT is an unconstrained environment

# Anomaly detection

- Key to ensuring resilience in an unconstrained environment
- Applied in robotics, vision, intrusion detection, industrial processes
- As well as wireless sensor networks

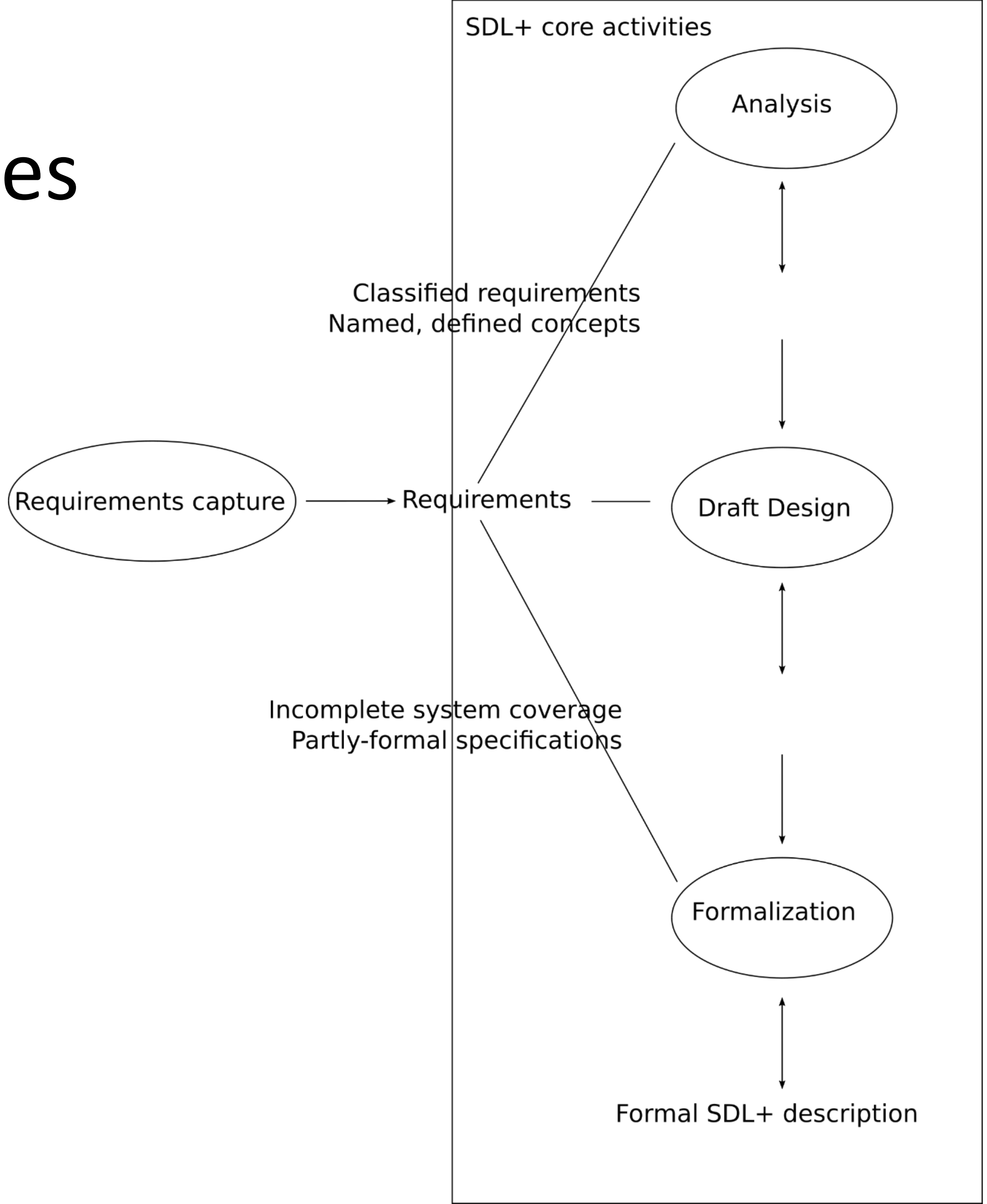
# Training and Testing

- Labelled data is essential to train and test an anomaly detection system
- Getting good training data is problematic
  - Real data is noisy
  - giving non-identical distribution of training samples
- Published data sets are useful
- Keeping them up to date is challenging

# Where SDL comes in

1. SDL+ as a method to create IoT systems with integral anomaly detection
2. SDL simulation as a source of high-quality bespoke training data

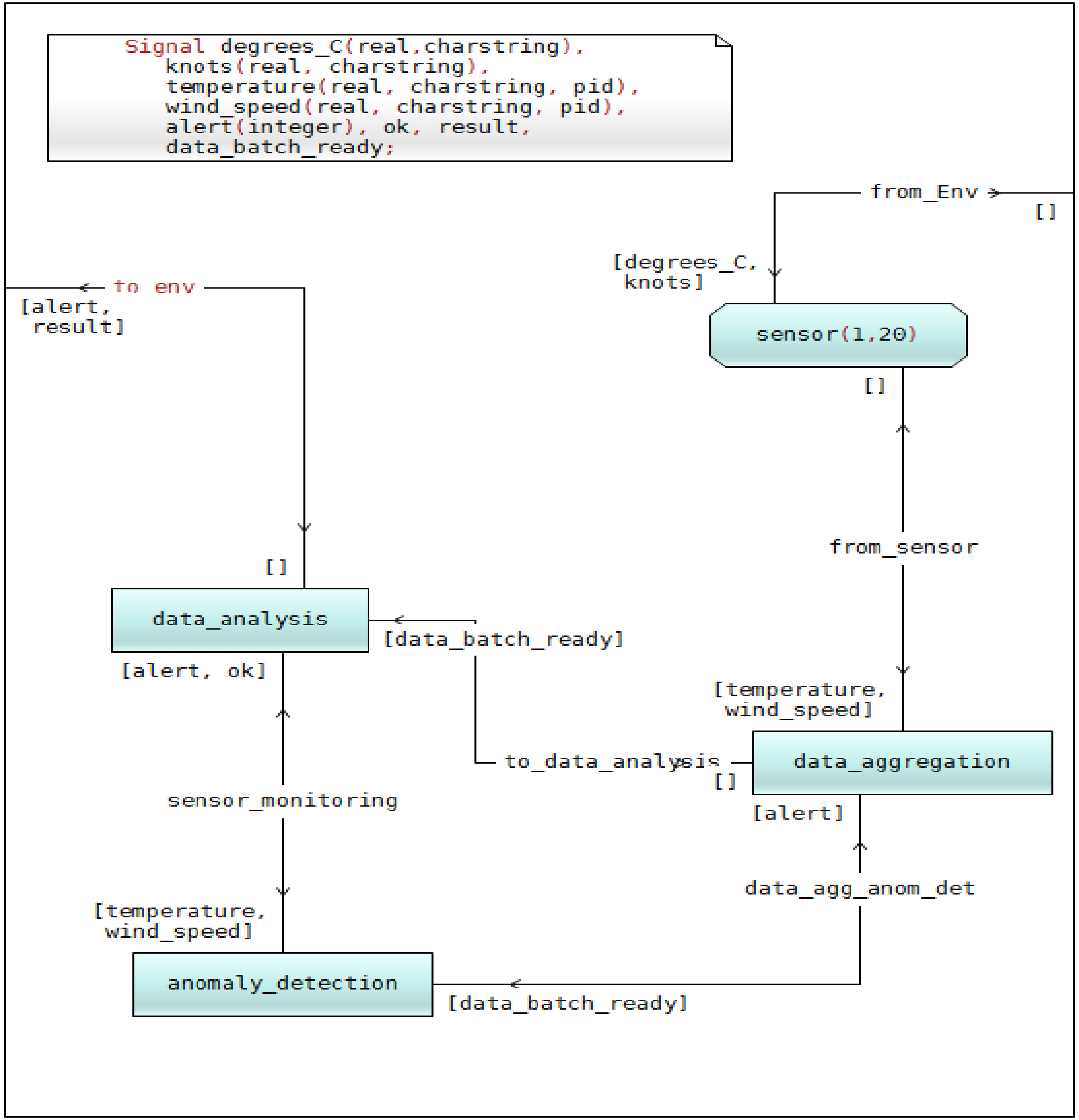
# SDL+ Core Activities



# SDL+ core activities

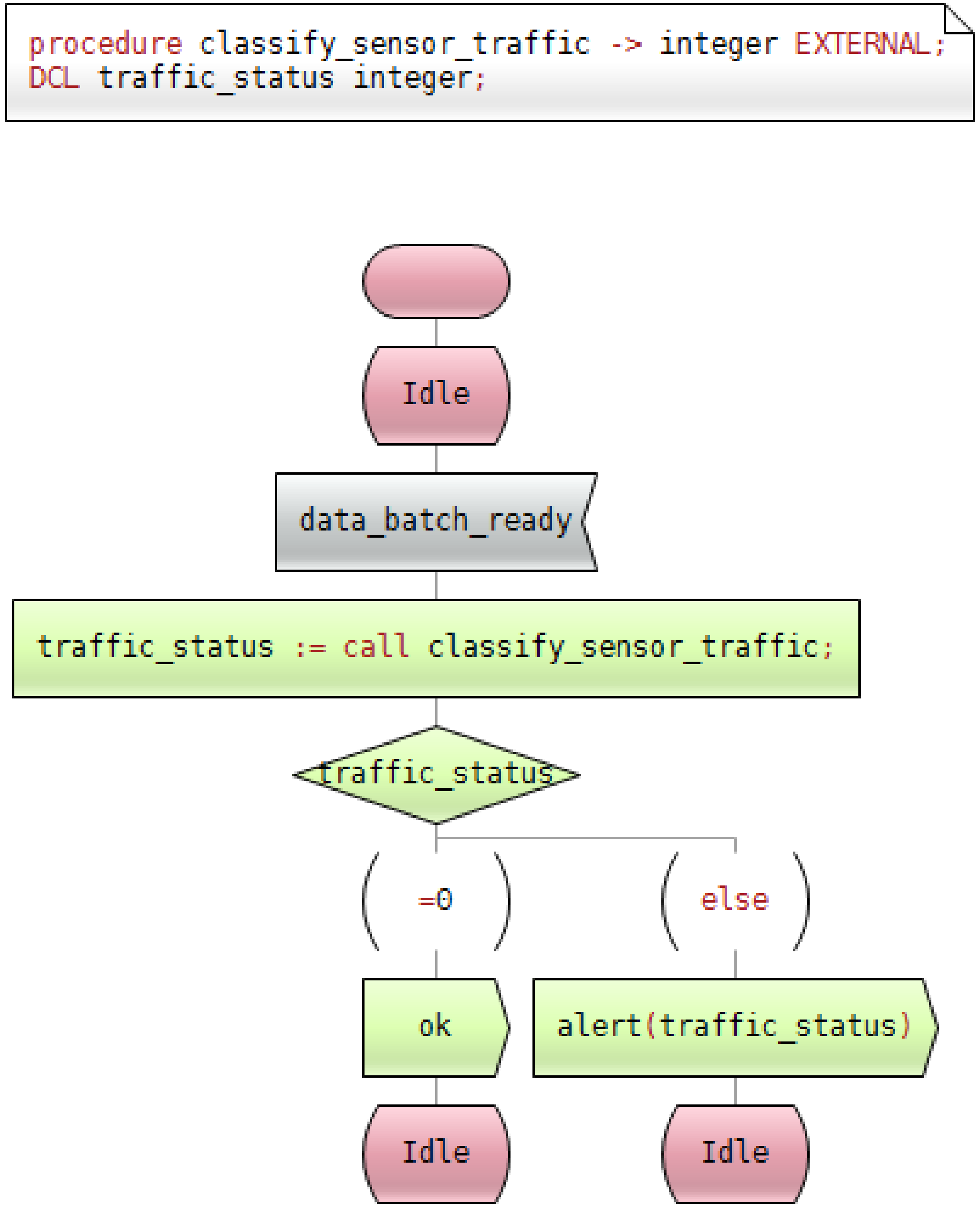
- Analysis
  - Concepts with names and definitions form an ontology
  - Used to identify threats and propose countermeasures
- Design
  - Explore vulnerabilities associated with different designs
  - Explore options for anomaly detection
- Formalization
  - Include anomaly detection in the formal description

# SDL model with external anomaly detection



```
Signal degrees_C(real,charstring),
    knots(real, charstring),
    temperature(real, charstring, pid),
    wind_speed(real, charstring, pid),
    alert(integer), ok, result,
    data_batch_ready;
```

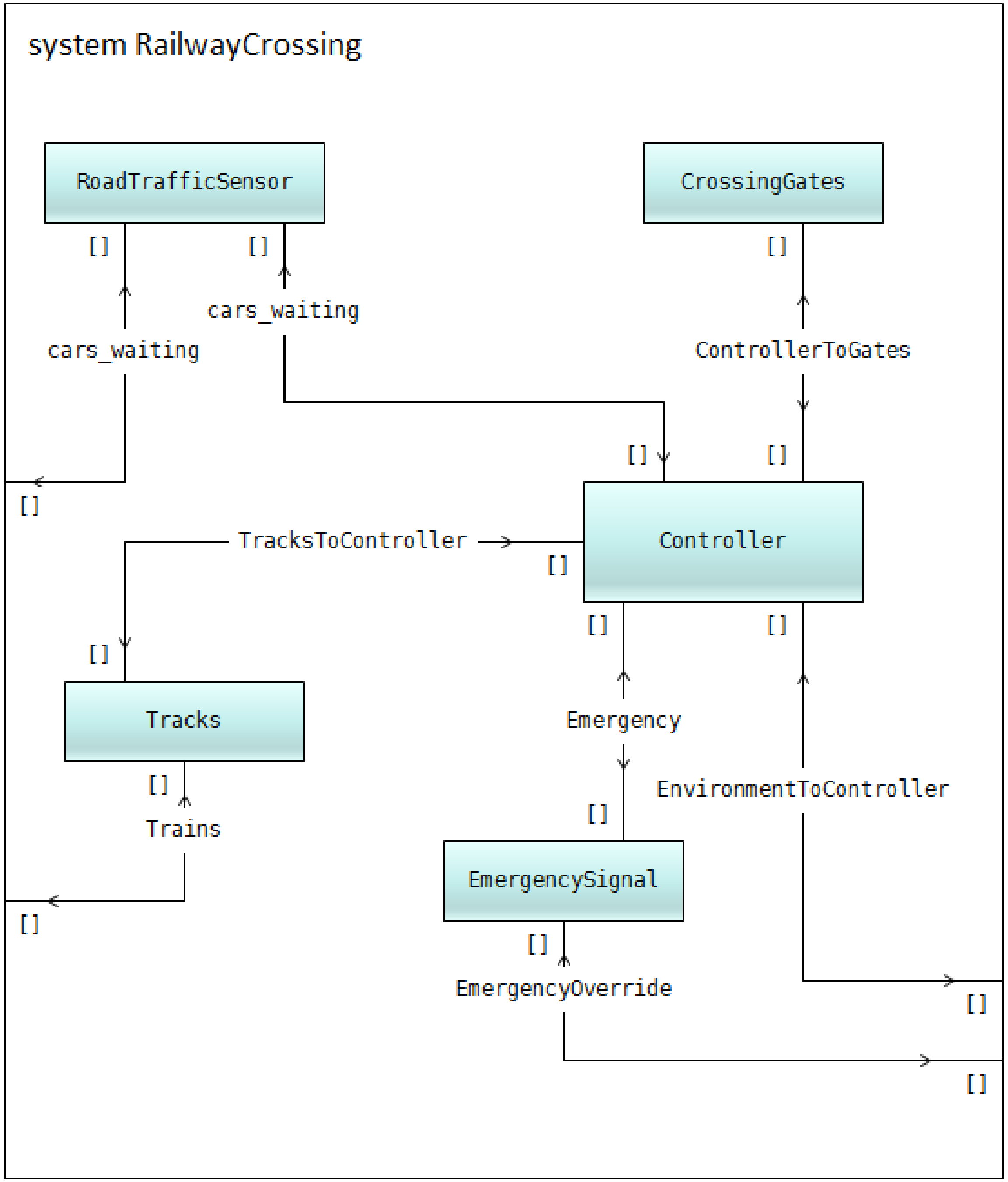
# External procedure classifies behaviour as normal or anomalous



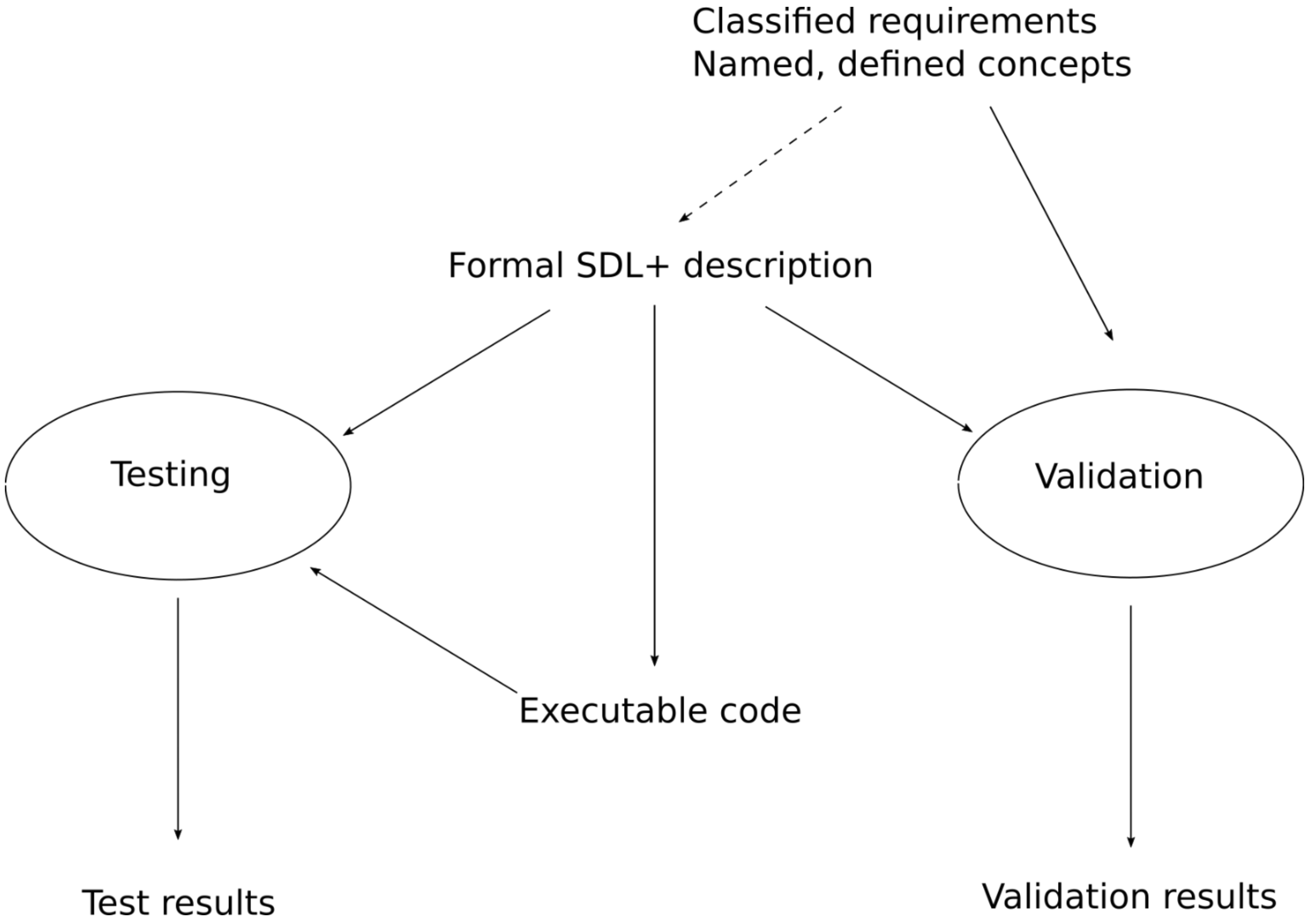
```
procedure classify_sensor_traffic -> integer EXTERNAL;
DCL traffic_status integer;
```

Design decision:

- include anomaly detection in the controller
- or distribute it across different system elements



# SDL+ model is validated and tested



# SDL+ testing and validation

- Both involve executing the SDL+ formal description
- Both use similar test cases
- Testing compares formal description with an implementation
- Validation compares formal description with classified requirements and with concepts from analysis

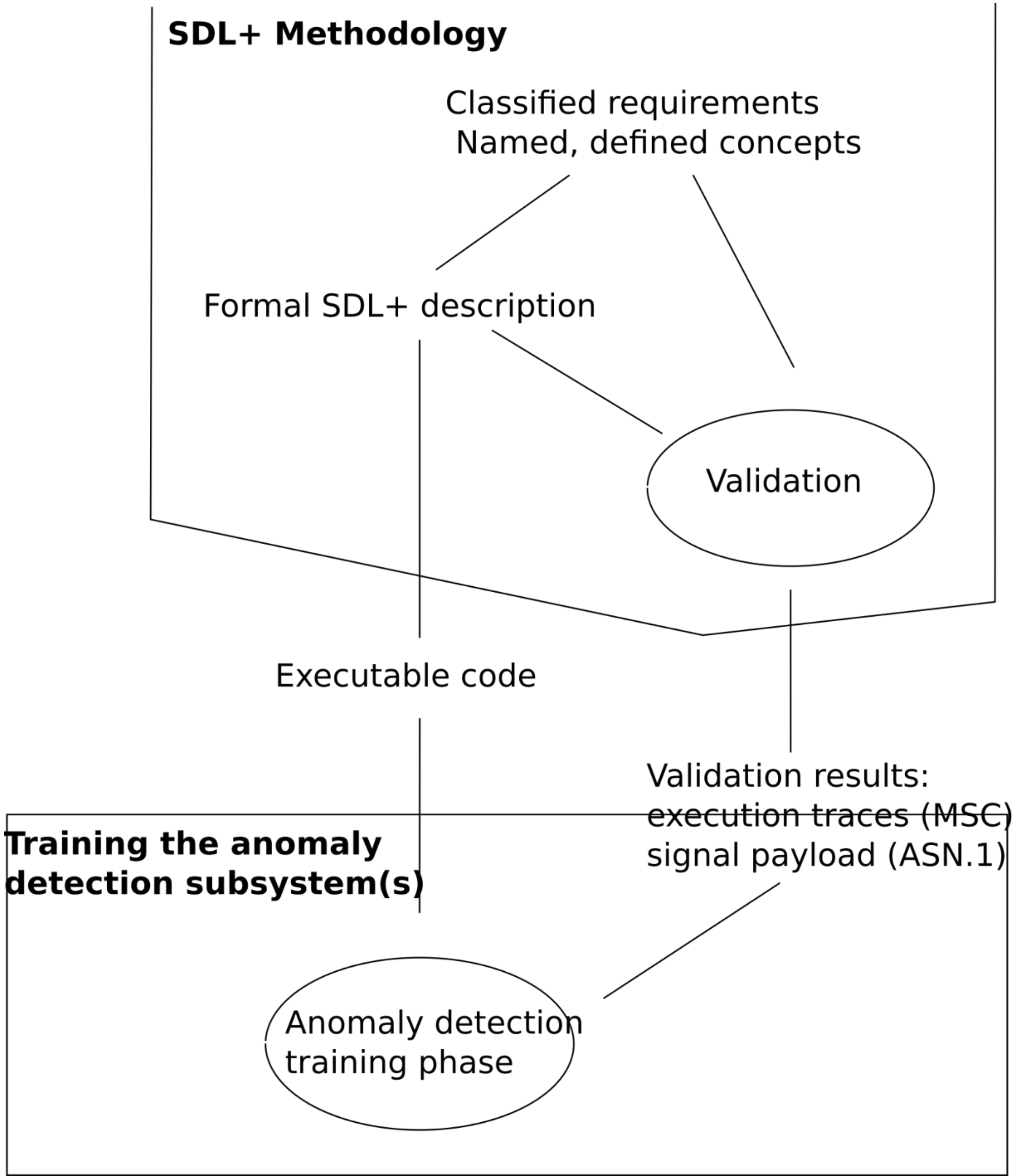
# Validation

- Check syntax and context conditions
- Check that requirements are addressed
    - Represent different environmental conditions as combinations of events
    - TTCN-3, MSC, SDL-2010
- Execute the SDL+ description

# Training data as a by-product of validation

- Validation results in execution traces
- Execution traces with signal payload constitute labelled training data

# Use the results of validation to train anomaly detection subsystem(s)



**SDL+ Methodology**

Classified requirements
Named, defined concepts

Formal SDL+ description

Validation

Executable code

Validation results:
execution traces (MSC)
signal payload (ASN.1)

**Training the anomaly detection subsystem(s)**

Anomaly detection training phase

# Testing the anomaly detection subsystem

- Re-frame an established data set as events
- Test the SDL+ formal description, with its anomaly detection system
- Evaluate the resulting traces

# But, so far, this is hypothetical

- Next step is to conduct some actual experiments
- For example, use the approach to re-create an existing IoT system, but this time with integral anomaly detection
- See how the resulting system behaves in the field

# Further empirical work

- Evaluate different kinds of anomaly detection
- Discover what constitutes an acceptable level of false positives
- Explore different responses to anomalous situations