Towards Cyber-Physical Systems as Services: the ASIP Protocol

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17 May 2015

The context

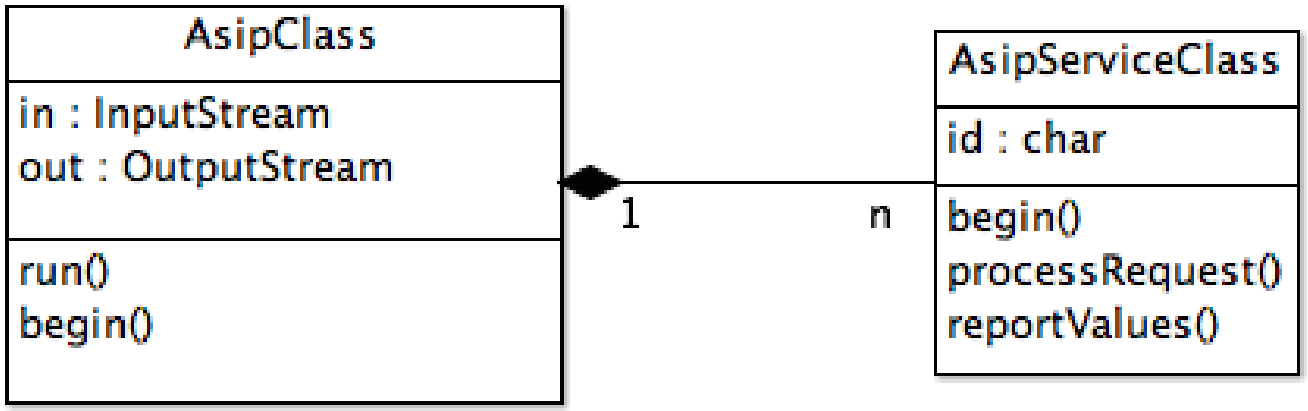
- Cyber-Physical Systems (CPS) are typically built using multiple interacting components (sensors for temperature, light, etc.)
- Components are connected to micro-controllers that often need to be programmed individually to meet a larger application's requirements.
- Focus of this work: expose "components" as services in resource-limited microcontrollers, such as Arduino (2 Kb RAM, approx 30 Kb flash space, no OS, etc.).

Related work

- ROS targets the integration of different platforms with support for a range of programming languages. However, mainly for robotic applications and requires computational resources (at least RPi latest model).
- TinyOS targets motes for WSN, with a typical footprint $>$ 30 Kb, beyond capabilities of most Arduino.
- Firmata is similar in spirit, but ASIP introduces higher level of abstraction and easier extensibility (textual vs 7-bit messages).

The ASIP service model

- A micro-controller should implement the AsipClass.
- An AsipClass is composed of one or more *services*, implementing an AsipServiceClass. Example of services: a distance sensor, servo motor, temperature sensors

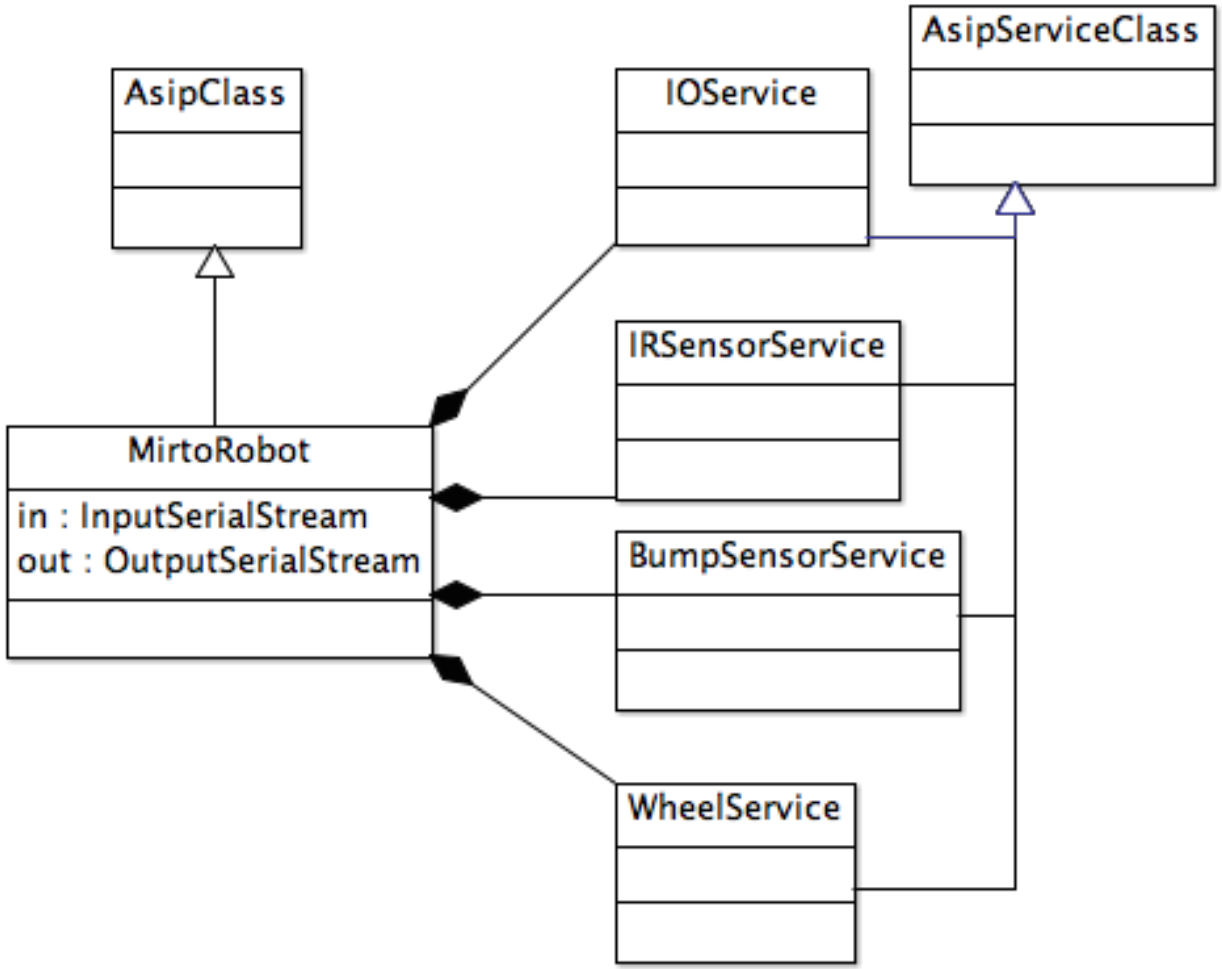


The main AsipClass loop

- The AsipClass on the microcontroller is connected to a stream (serial, recently TCP and MQTT as well).
- Messages are received and sent over this stream.
- The AsipClass dispatches incoming messages to the appropriate service.
- Structure of a message: `serviceID,operation,listOfValues`
  Example: `I,d,13,1`
- See `http://github.com/michaelmargolis/asip` for formal syntax of messages.
- We provide a number of service, but additional ones could be defined by implementing an AsipServiceClass to handle appropriate messages.

Example: uploading ASIP to a microcontroller for a Robot

Example: UML class diagram for the robot



Example part 2: using a client (Java)

```
1  SimpleTCPBoard board1 =
2      new SimpleTCPBoard("192.168.0.2");
3  SimpleTCPBoard board2 =
4      new SimpleTCPBoard("192.168.0.3");
5  // [...] SETUP HERE [...]
6  while (true) {
7    buttonState = board1.digitalRead(buttonPin);
8    if ((buttonState == HIGH) {
9      board2.digitalWrite(ledPin, AsipClient.HIGH);
10   } else) {
11     board2.digitalWrite(ledPin, AsipClient.LOW);
12   }
13 }
```

Example 3: coordination

https://www.youtube.com/watch?v=TVZpqKEnv4I

In summary

- An abstraction for resource-limited microcontrollers that enables faster application of CPS by composing *services*.
- Open source implementation of core ASIP and a number of services.
- Clients in Java, Python, Racket, Erlang.
- Serial communication and experimental TCP sockets and MQTT (pub/sub) messaging.
- Enables model-based and model-to-code development of CPS.
- Allows dynamic reconfiguration of complex applications.
- Currently working on model-to-code transformation to support certification activities.

Thanks! Questions?

- Arduino ASIP available at `https://github.com/michaelmargolis/asip`
- Clients:
  - Java: `https://github.com/fraimondi/java-asip`
  - Python: `https://github.com/gbarbon/python-asip`
  - Racket: `https://github.com/fraimondi/racket-asip`
  - Erlang: `http://github.com/ngorogiannis/erlang-asip`
- Examples and tutorials available at `http://www.rmnd.net`
- Please contact us at `http://mase.cs.mdx.ac.uk` for queries and additional information.