REALTALK: Language Support for Long-Latency Operations in Embedded Devices

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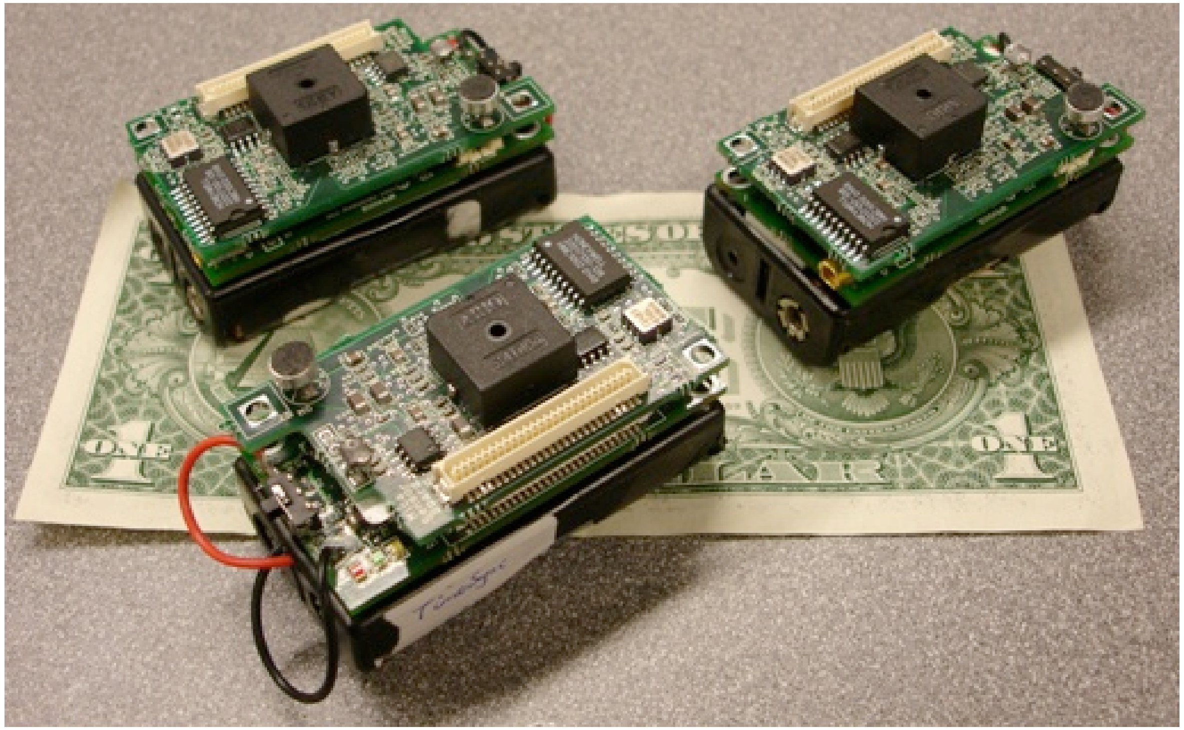
Outline

1. Wireless embedded sensor device
2. The Realtalk programming language
3. Benefits of Realtalk
4. Implementation based on TinyOS
5. Conclusion

Wireless sensor device



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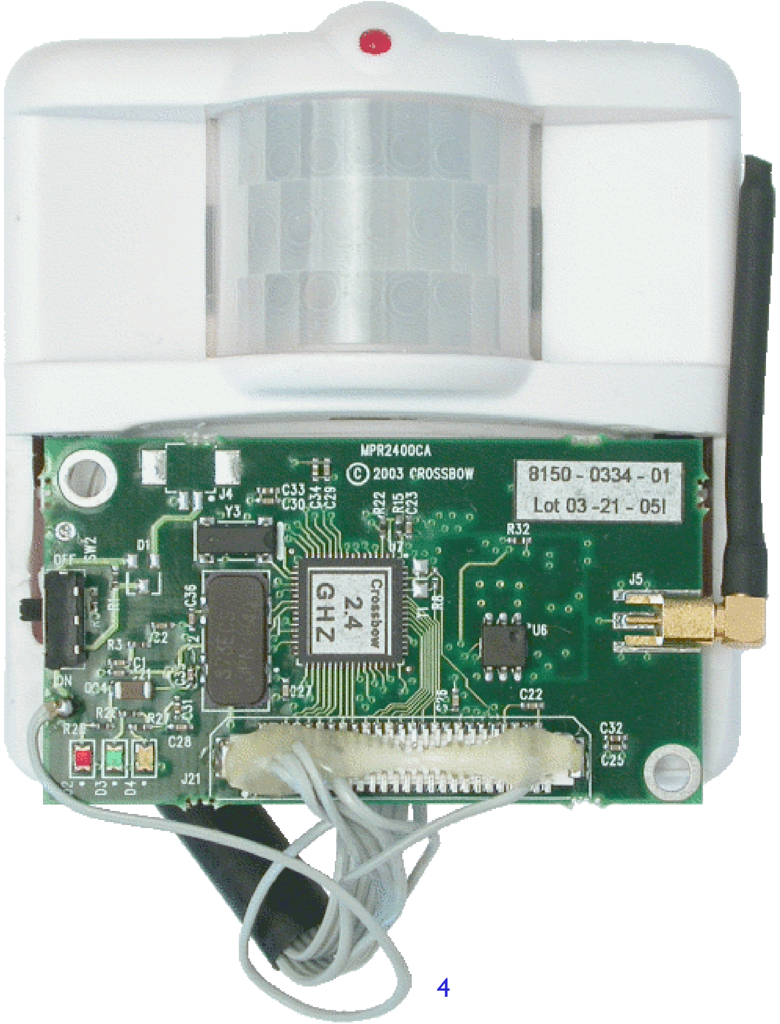
Wireless sensor device



Programming wireless sensor devices is difficult

- Limited resources (energy, memory)
- Asynchronism between electronic elements (sensors, micro-controller)

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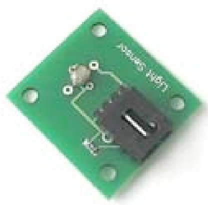
Signal

Request

for a sampling



Program execution

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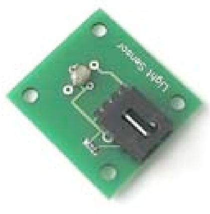
Program execution



Environment being sampled

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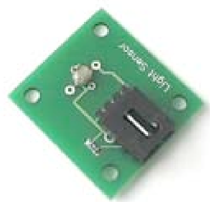
Programming wireless sensor devices is difficult

- Limited resources (energy, memory)
- Asynchronism between electronic elements (sensors, micro-controller)

Signal

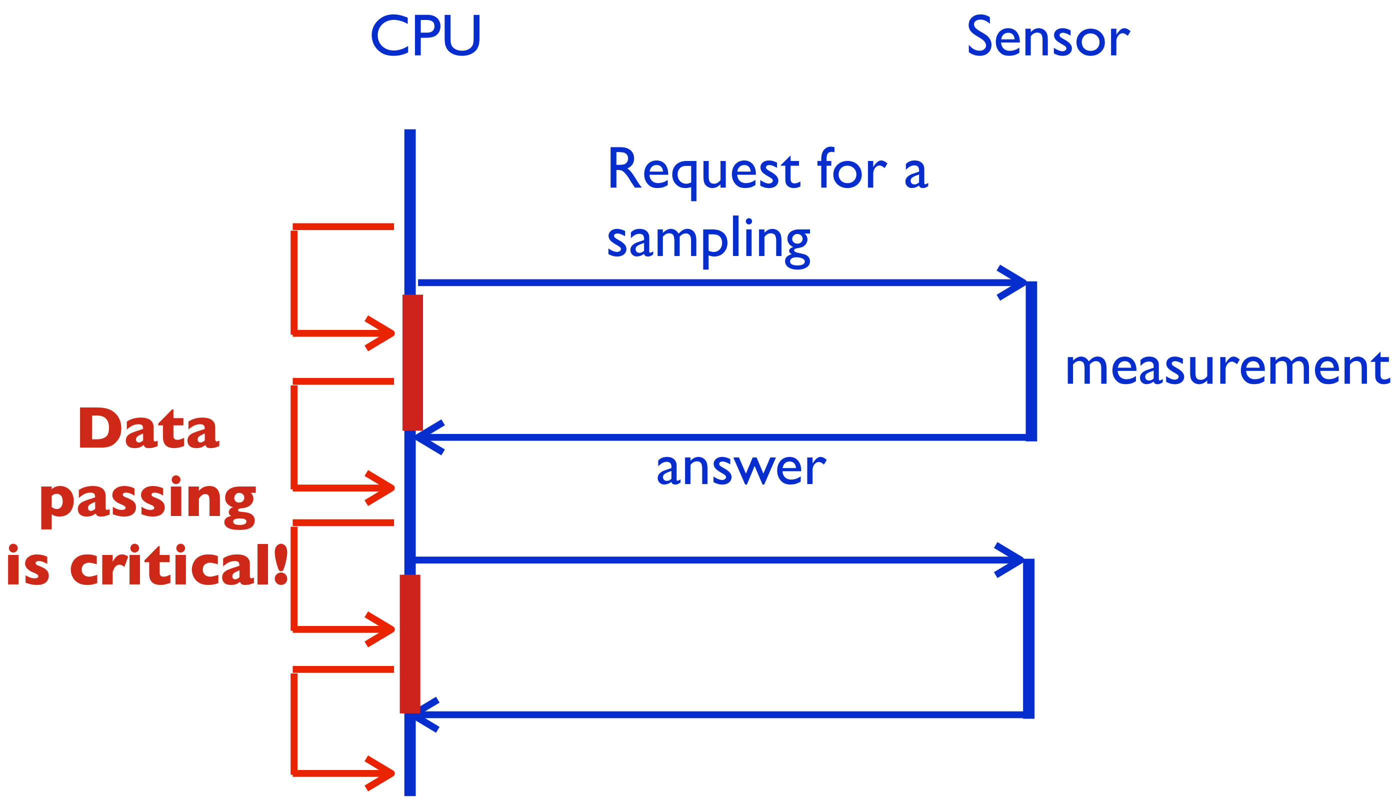
Sampling

transmitted



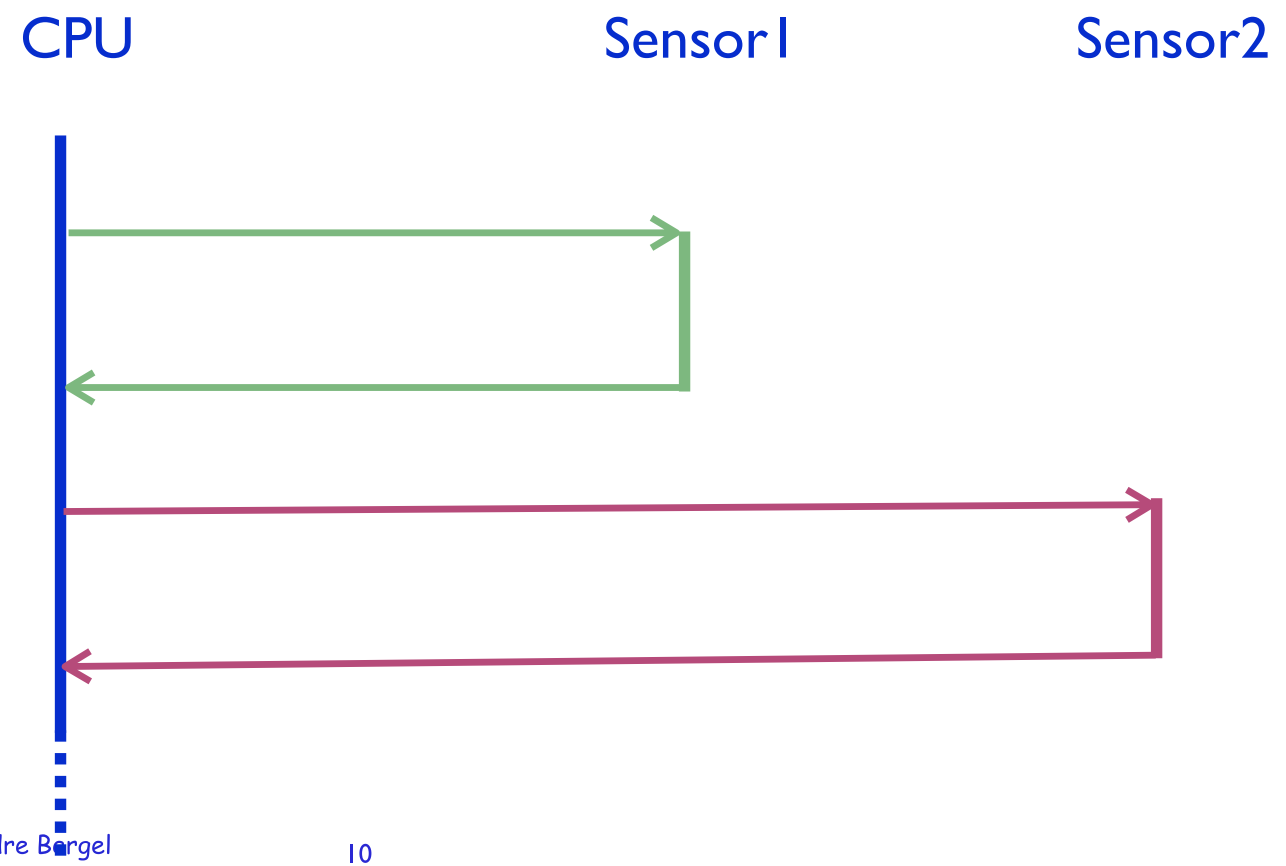
Program execution

Disruption in the control flow: data passing



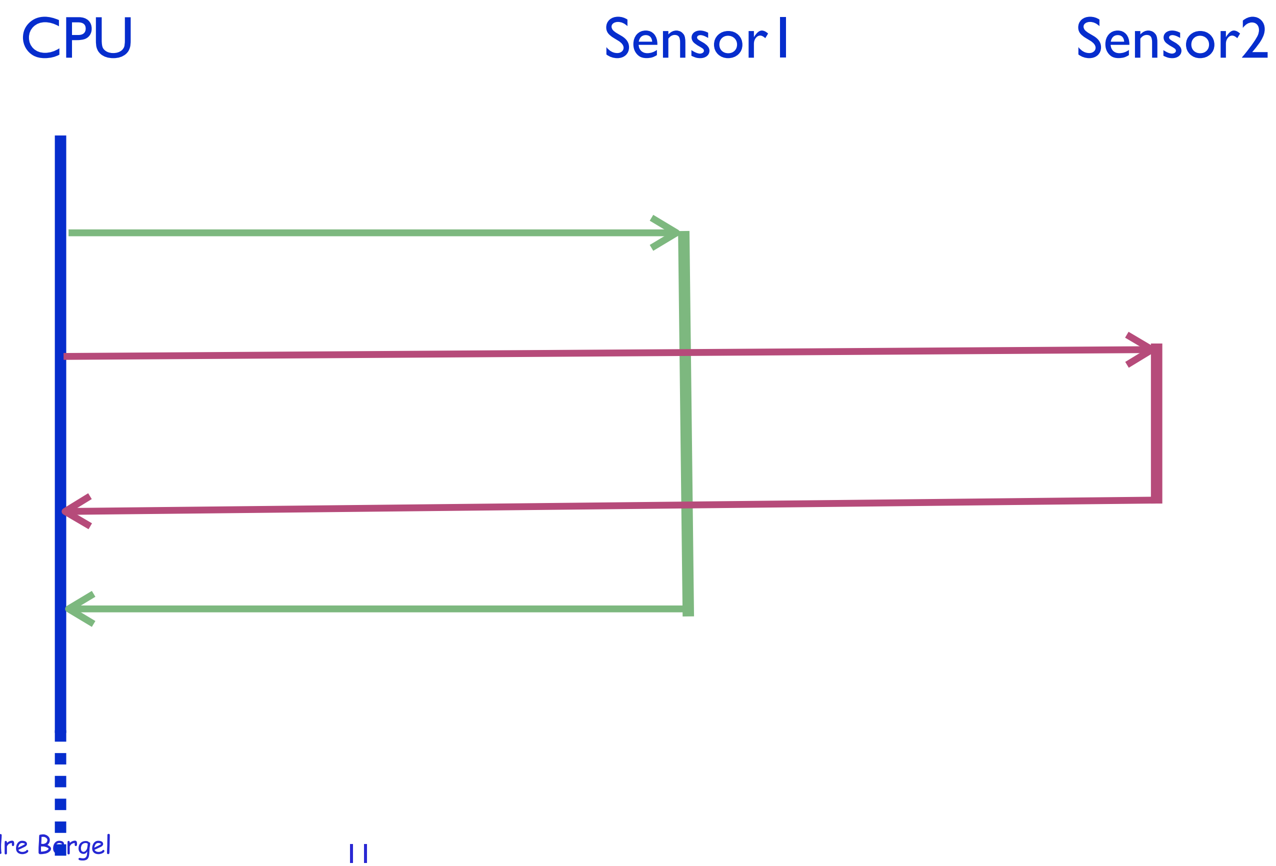
Disruption in the control flow: sequence ordering

What we would like to have...

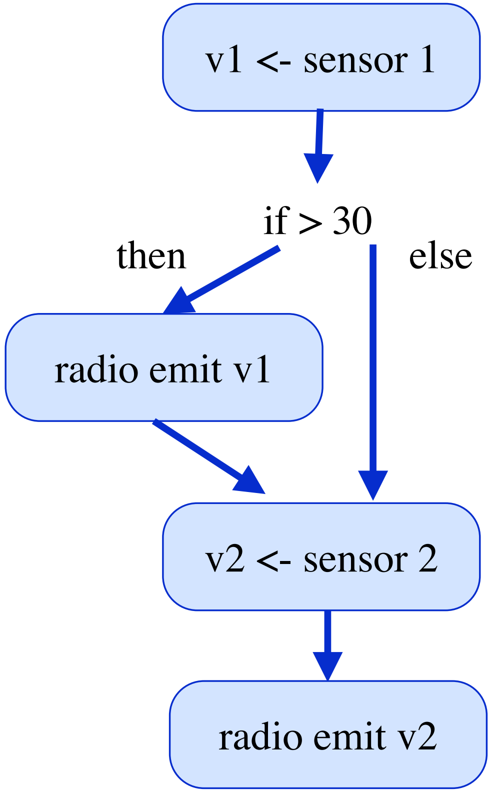


Disruption in the control flow: sequence ordering

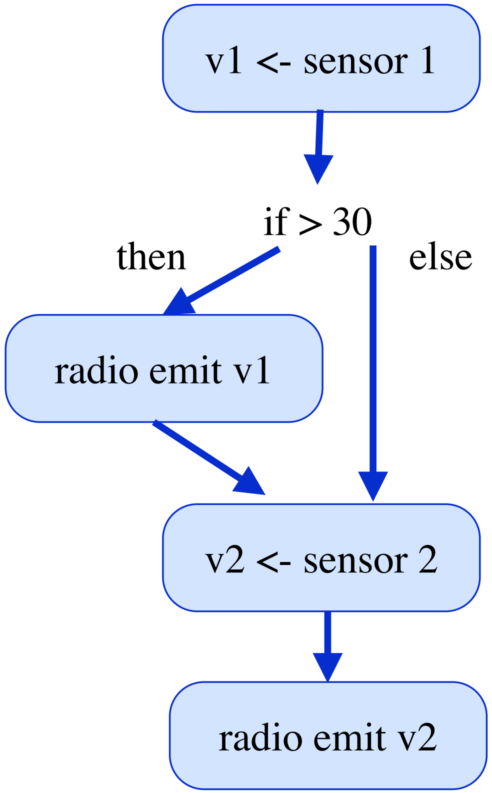
... but it is difficult to prevent this:



Example in nesC-like language



Example in nesC-like language




```
int controlFlowState = 0;
start {
  call Sensor1.getData();}

Sensor1.dataReady(v1) {
  if (v1 > 30)
    call Radio.emit(v1);
  call Sensor2.getData();}

Radio.emitDone() {
  if(controlFlowState == 0){
    controlFlowState = 1;
    call Sensor2.getData();}}

Sensor2.dataReady(v2) {
  controlFlowState = 1;
  call Radio.emit(v2);}
```

Ideas of Realtalk: controlled disruption

- Use of a light-weight continuation mechanism (kind of co-routine)
- *At compile time:* function body is cut into fragments
- *At runtime:* Fragments are inserted into a queue at runtime to be sequentially processed

Realtalk: modelling electronic elements as objects

```
RTObject subclass: #SensingApplication
  variableNames: 'sensor1 sensor2 radio timer'

SensingApplication main {
   timer invoke: #sample every: 500
}

SensingApplication sample {
  | v1 v2 |
  v1 := sensor1 read.
  v2 := sensor2 read.
  radio broadcast: (v1 + v2)
}
```

Realtalk: modelling electronic elements as objects

```
SensingApplication subclass: #BlinkingApplication
  variableNames: ‘leds’
  aliases: { #sample -> #readAndSend}.


BlinkingApplication sample {
  self readAndSend.
  leds greenToggle.
}
```

Classes are instantiated at compile-time only

```
"Deploying BlinkingApplication"

BlinkingApplication composeWith: {
   #leds    -> Leds .
   #timer   -> Timer .
   #sensor1 -> LightSensor .
   #sensor2 -> SoundSensor
}
```

Long latency operations are statically defined

```
LightSensor read {
  <AsynchronePrimitive>
  “mapping from LightSensor read to
Photo.getData(…)“
  ...
}
```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Controlled disruption: an overview

- At compile-time:
  - Use of long latency operations is localised
  - Methods are cut into an ordered set of small fragments

- At run-time:
  - When a long-latency operation has completed, the next fragment is processed
  - Method contexts hold dynamic information (i.e., local variables, …)

Example of controlled disruption

```
SensingApplication readingTwoSensors {
   | value1 value2 |

   leds display: 1.
   value1 := lightSensor read.

   leds display: 2.
   value2 := soundSensor read.

   leds display: 3.
   radio broadcast: (value1 + value2).
}
```

1 - Long latency operations are localised

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SensingApplication readingTwoSensors {
   | value1 value2 |

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```


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2 - Methods are cut into fragments

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3 - Fragments are inserted into the queue

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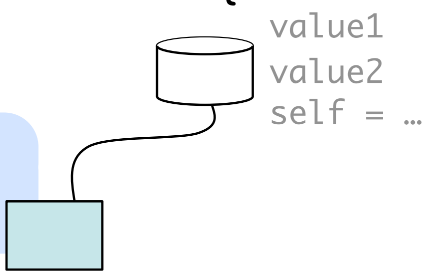

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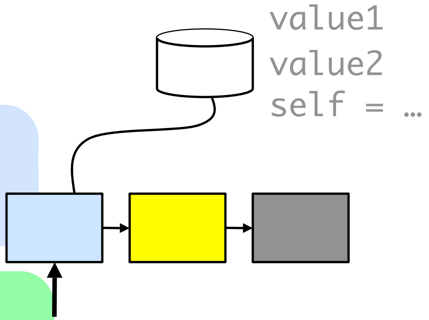

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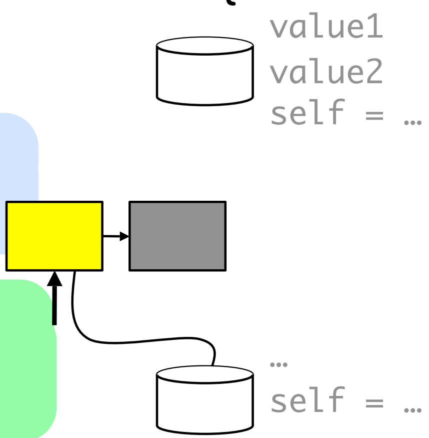

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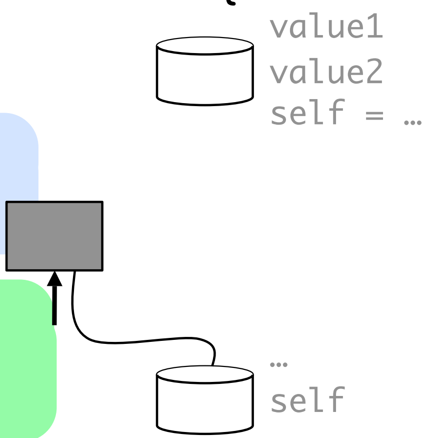

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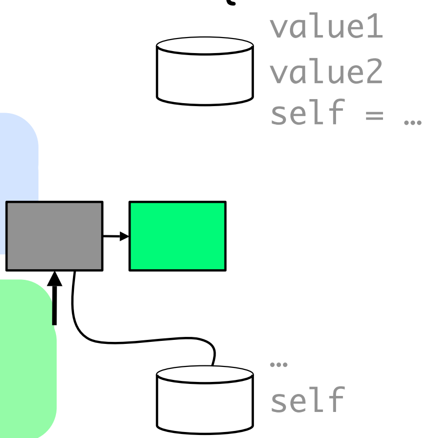

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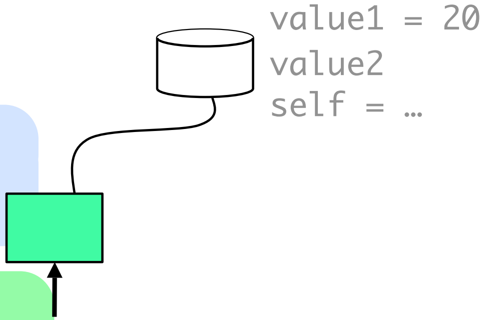

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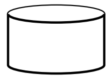

value1 = 20
value2
self = …

3 - Fragments are inserted into the queue

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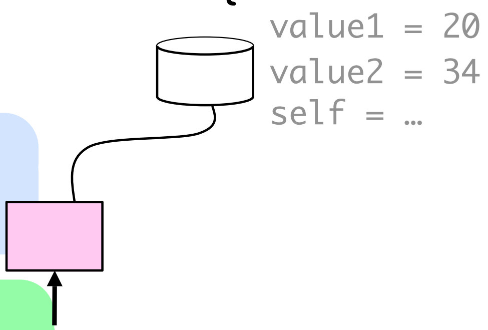

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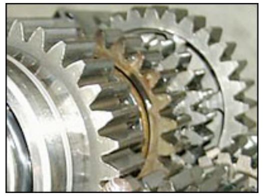
Benefits of controlled disruption

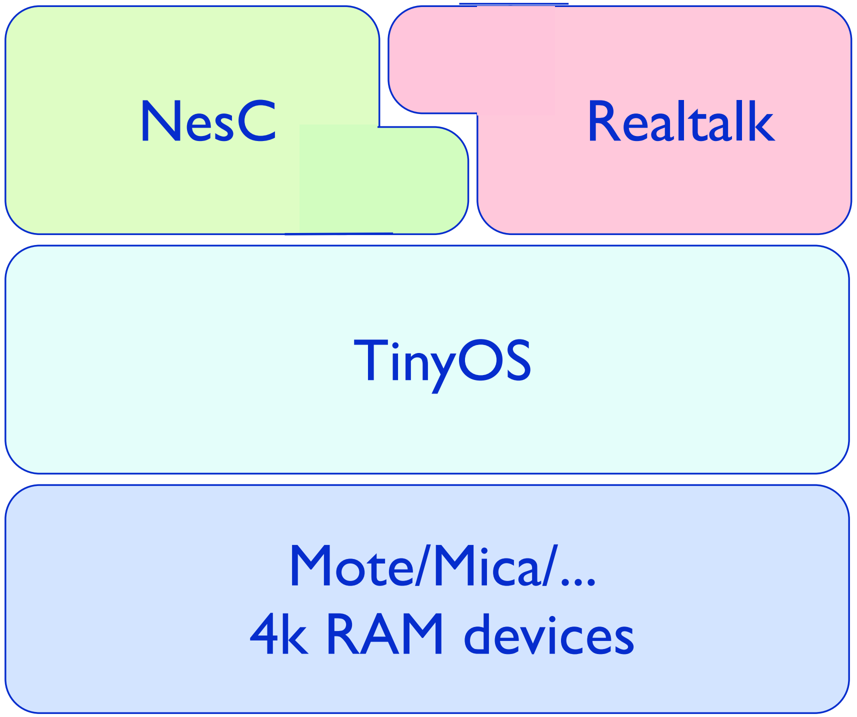
- Long-latency operations are blocking
- Data passing is achieved through the lexical scope of variables
- Sequence ordering reflects the application‘s control flow

Low memory overhead

Applications	Realtalk	nesC	ratio
CounterTo Leds	1532+46	1570+46	0.97
RadioToLeds	2382+81	2348+67	1.01
CounterToLeds AndRadio	9674+354	9398+384	1.02
SensorToRadio	10088+356	9618+386	1.04



Implementation based on TinyOS/NesC



- Compiler available: www.bergel.eu/realtalk.html

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Conclusion

- Realtalk is a programming language dedicated to small sensor devices
- Control flow of program reflects the control flow of the application
- Generated programs do not have any overhead
- On going work focuses on the effect of polymorphism and method context generation regarding battery consumption.