Cluster 3 – Networked software systems

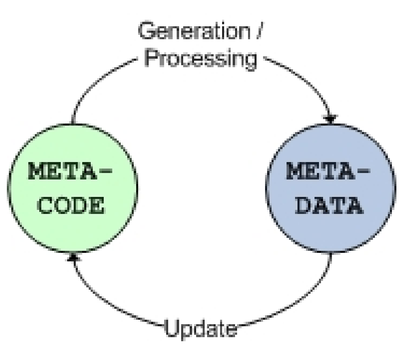
Using Meta-Code for Building Task-Specific WSNs

Igor Talzi, Christian Tschudin / University of Basel, Computer Science Dept
Andreas Hasler, Stephan Gruber / University of Zürich, Dept of Geography
Jan Beutel, Mustafa Yücel, Roman Lim / Computer Engineering and Networks Lab, ETH Zurich

Introduction

Meta-code definition:

- Meta-code deals with the meta-data, or
- Meta-code describes behaviour, the actual implementation is still based on the native code.



The potential use:

- Auto-configuration (react to changes in topology, sensor attachments, etc)
- Self-documenting (report changes)
- Proactive actions

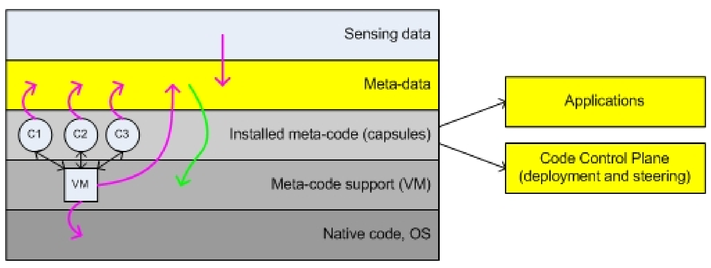
Code/Data «Sandwich»

Mainly, we focus on

- Meta-data management,
- Code Control Plane [CCP] for code deployment and steering,
- Meta-code compression.

Meta-data management:

- Network configuration (topology, faults, etc)
- Software versioning
- Instruction set dictionary
- User-defined structures



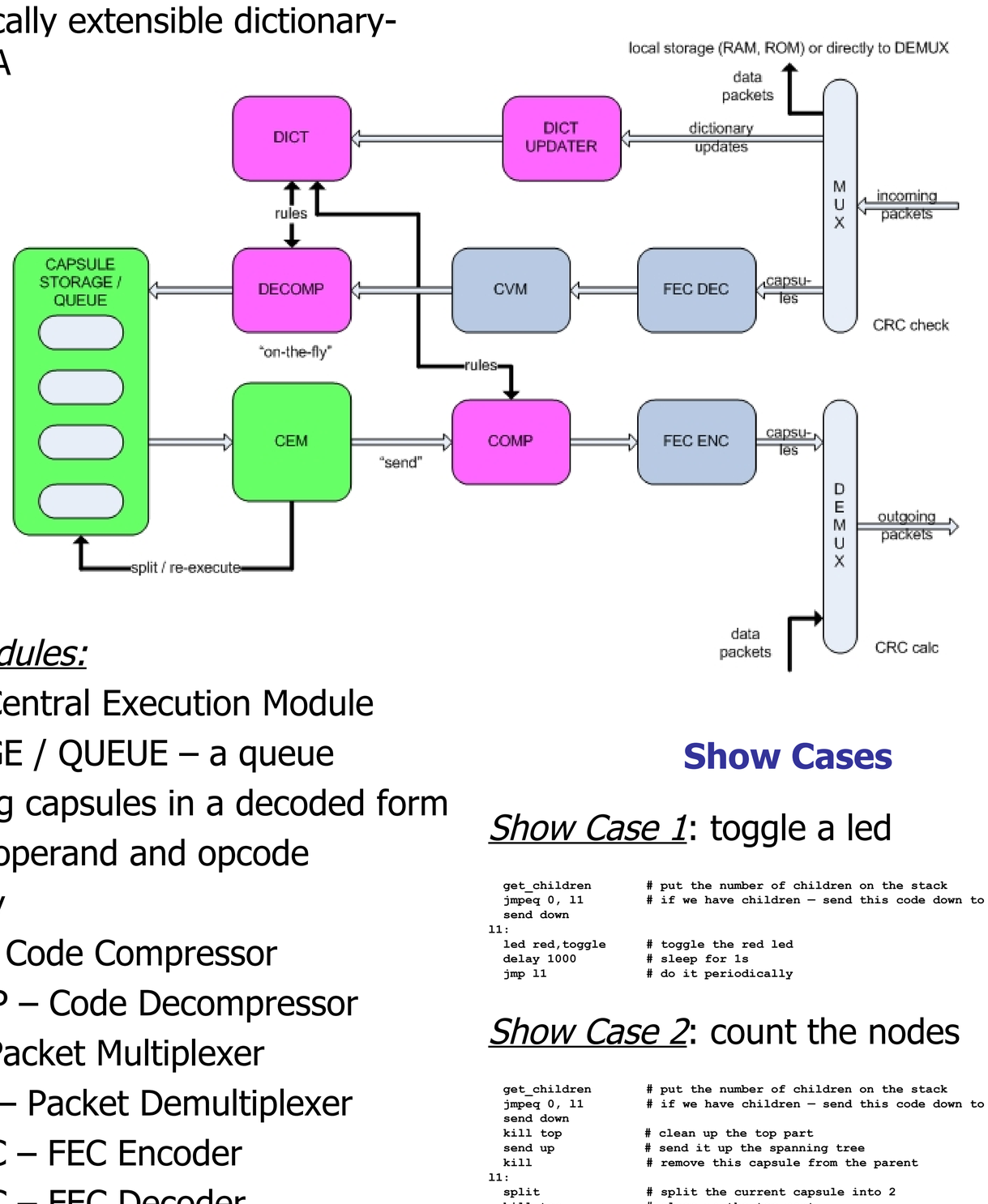
Code Control Plane [CCP]:

- Track changes, on-demand requests
- Uses meta-data layer for storage
- Creates reports

Node Architecture

Basic principles:

- Stack-based VM
- Shared memory for vars (heap)
- Memory protected capsule execution
- FIFO-like scheduling, blocking operations (e.g. «delay N» or «send_dt up»), direct access to the queue
- Errors are reported to the meta-data layer
- Dynamically extensible dictionary-based ISA



Basic modules:

- CEM – Central Execution Module
- STORAGE / QUEUE – a queue containing capsules in a decoded form
- DICT – operand and opcode dictionary
- COMP – Code Compressor
- DECOMP – Code Decompressor
- MUX – Packet Multiplexer
- DEMUX – Packet Demultiplexer
- FEC ENC – FEC Encoder
- FEC DEC – FEC Decoder
- CVM – Code Validation Module

Instruction Set

Basic instructions:

- Stack ops («push», «pop»)
- Heap ops («read», «write», «move», etc)
- Arithmetic ops («add», «mult», etc)
- Binary\Logic ops («and», «xor», etc)
- Jumps («jmpeq 7,L1», «jmp L2», etc)
- Debug («led green,off»)
- Macro-instructions

Macro-Instructions

Command	Semantics
send_dt/code up/down	Send the current capsule (CODE) or the stack content (DATA) up/down the spanning tree
get_meta_dt F	Get meta-data field F
mod_meta_dt F,V	Modify/create meta-data field F with value V
split	Split the capsule into 2 at the current position
merge A,B	Merge capsules A and B
copy L,ADDR	Copy the code from the current position to the label L and send it to the address ADDR (broadcast, unicast)
kill "/top/bottom	Remove the entire capsule, or its top, or a bottom part
wr/rd/rm_dict	Write/read/remove a record from the instruction dictionary
ping ADDR	Ping a node
get_children	Get the list of available children nodes

Show Cases

Show Case 1: toggle a led

```
  get_children        # put the number of children on the stack
  jmpeq 0, 11         # if we have children – send this code down to them
  send down
11:
  led red,toggle      # toggle the red led
  delay 1000          # sleep for 1s
  jmp 11              # do it periodically
```

Show Case 2: count the nodes

```
  get_children        # put the number of children on the stack
  jmpeq 0, 11         # if we have children – send this code down to them
  send down
  kill top            # clean up the top part
  send up             # send it up the spanning tree
  kill                # remove this capsule from the parent
11:
  split               # split the current capsule into 2
  kill top            # clean up the top part
  send up             # send it up the spanning tree
```

(the code for counting incoming capsules at the top of the tree is not shown)

Code Compression

`ping ADDR`	`push 3`
	`11:`
	`get_nodeid`
	`report ADDR`
	`delay 1000`
	`dec`
	`jmpneq 0,11`

`report ADDR`	`get_meta_dt ADDR` `send_dt up`

Future Work

- Obtaining initial results on simulation
- More complex show cases (e.g. skew-balance time sync protocol)
- Power profiling

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