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Automatic Exploration of Hardware/Software Partitioning

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Chair for
Chip Design for
Embedded Computing

Design Space

Designer
Experience

Right Design

Source:binoculas.net

DSE Strategies

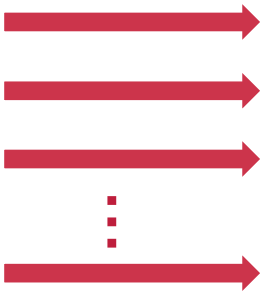
Exhaustive Search:
- Simulate all the possible designs then choose the best one among them (Minimum Energy Delay Product)

Source: ayehu.com

$$ES_{total\_simulations} = \prod_{i=1}^{N} n_i$$

Time consuming
Can take days !

Design Parameters



Optimal solution

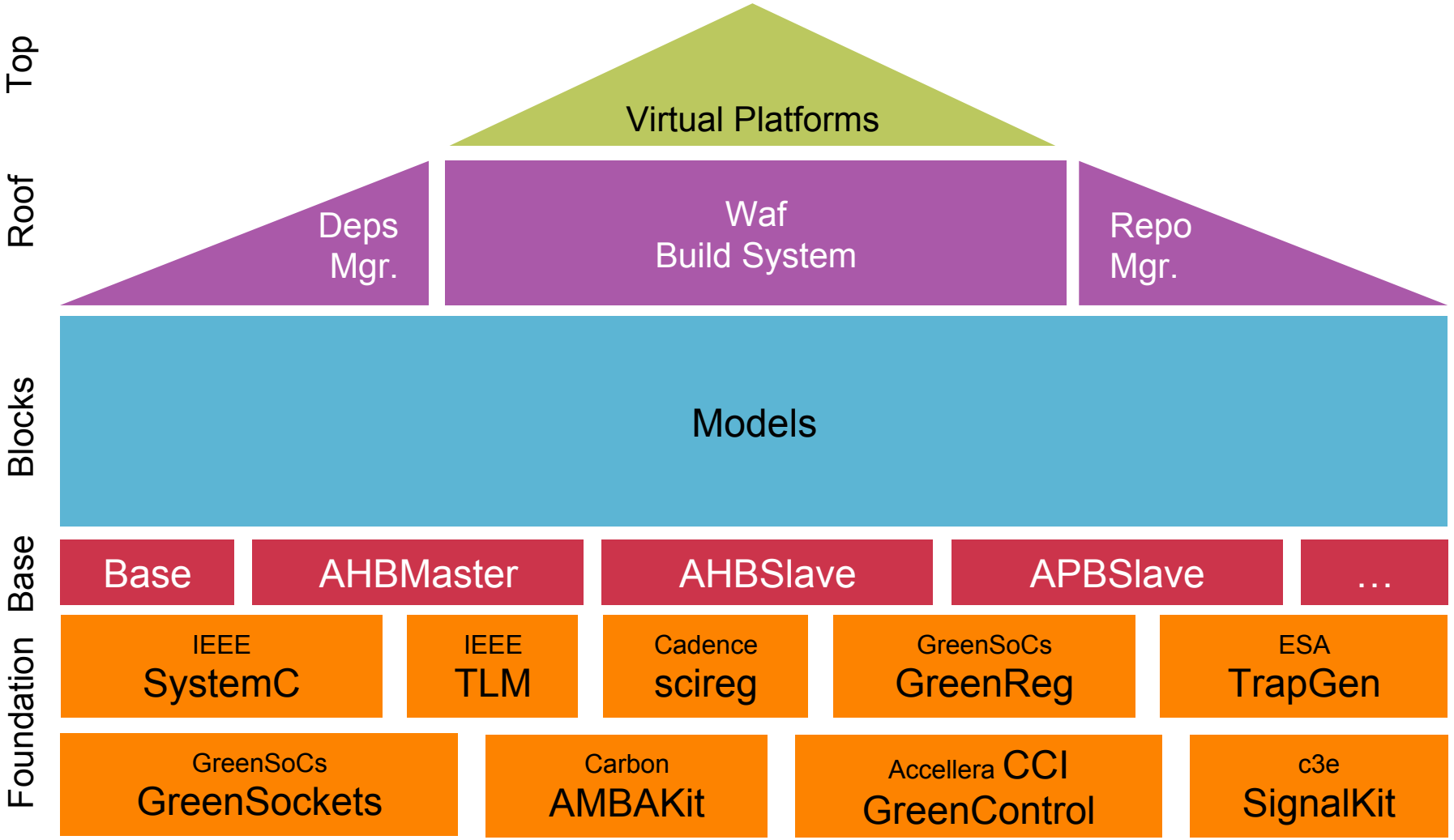
Less number of simulation
=> Less time

Solution

Give the Designer more freedom ; being involved as less as possible in the MPSoC design Space Exploration

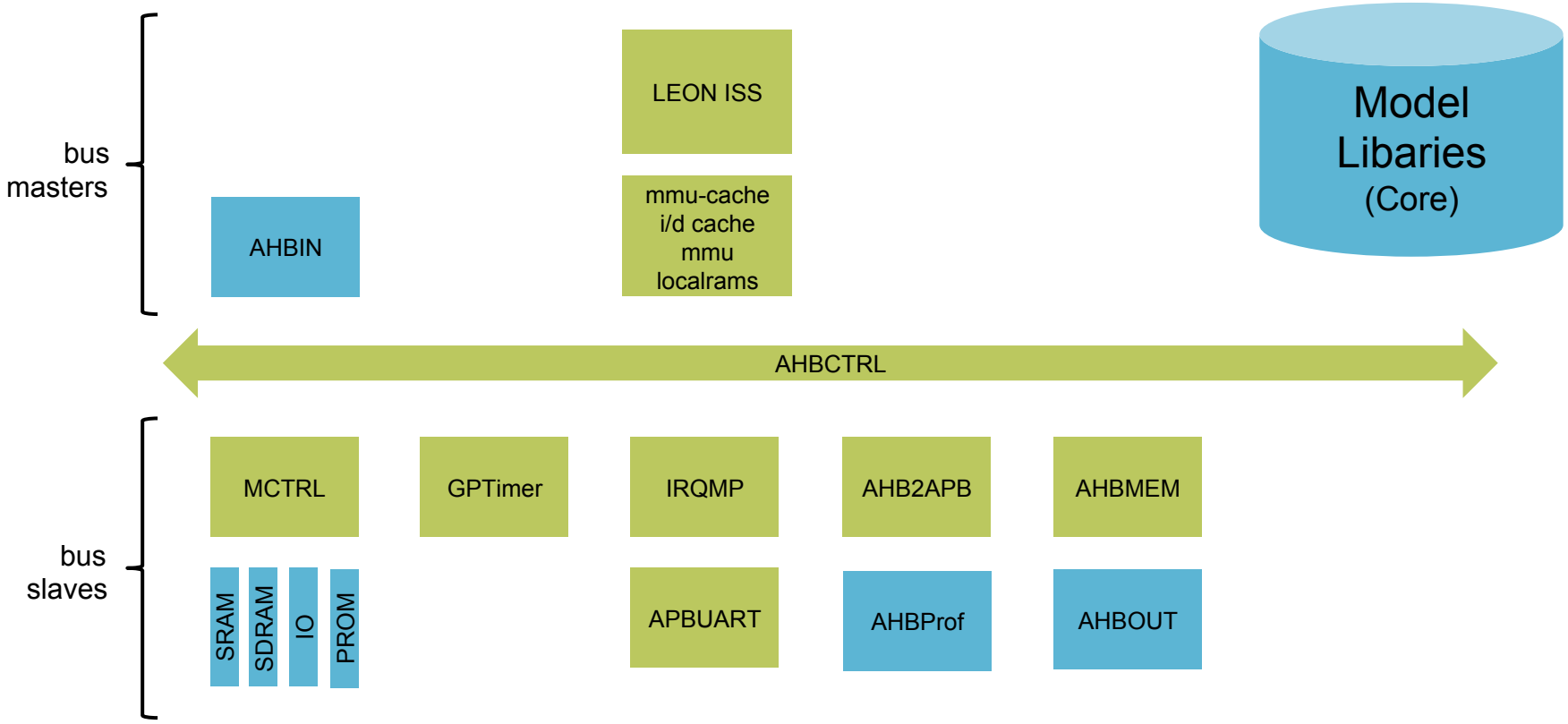
SoCRocket - The building blocks

SoCRocket is more than a model library



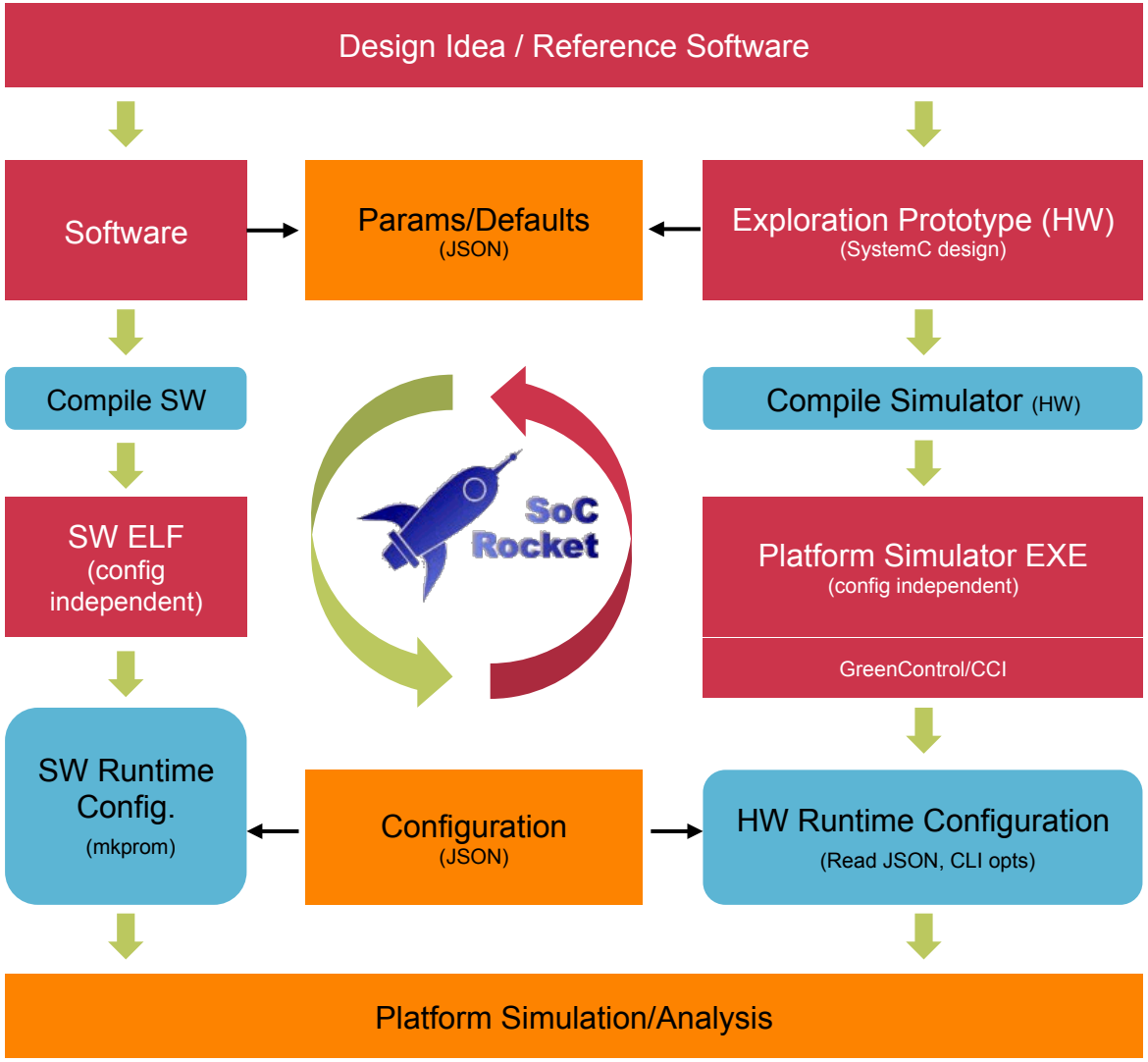
Included SystemC Models (core)

All models where developed with RTL equivalents as blueprint



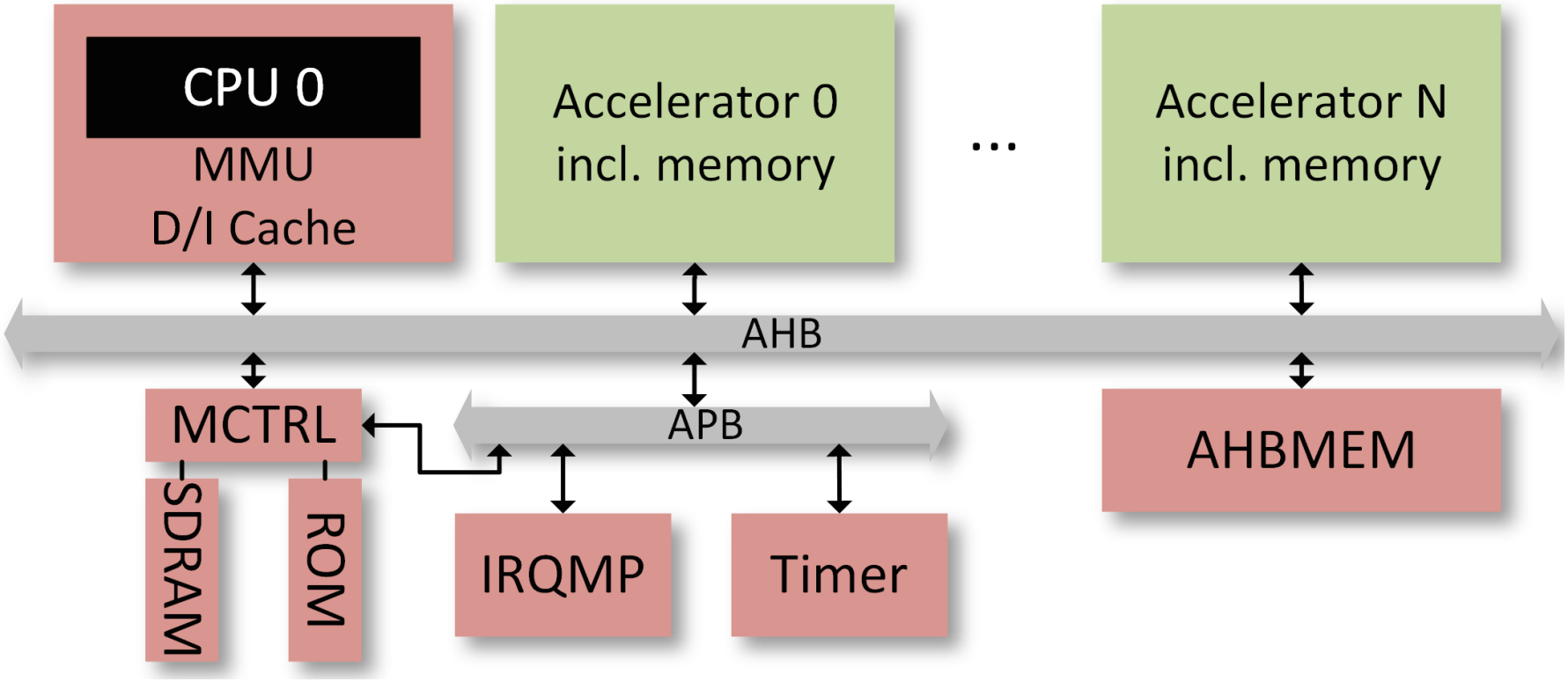
SoCRocket - DSE Flow

Runtime re-configuration

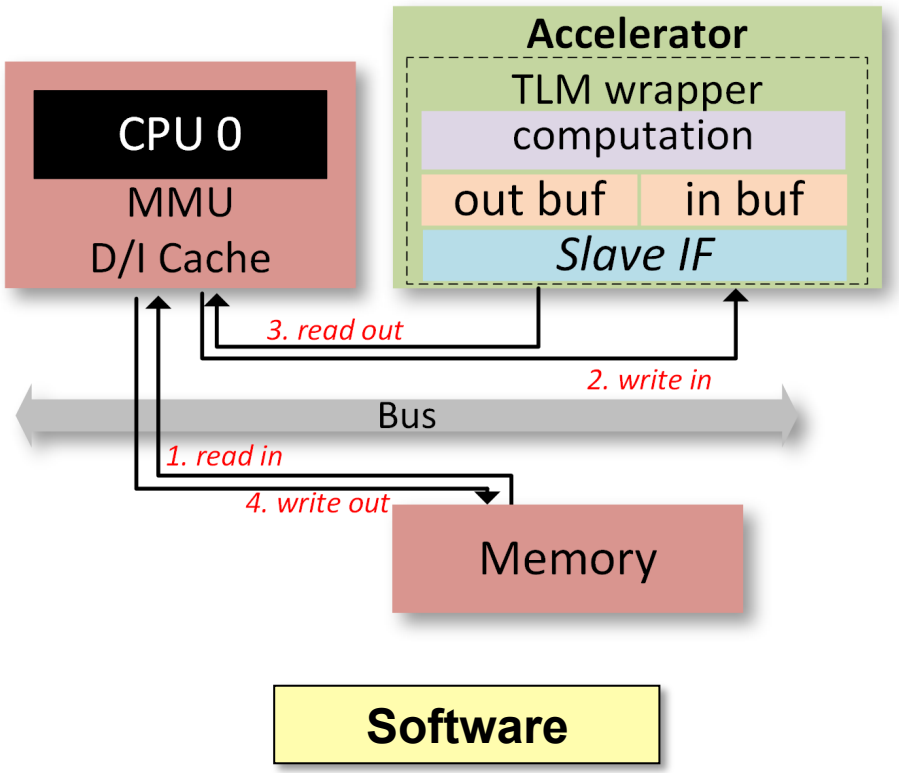


(From SoCRocket Design Flow Report)

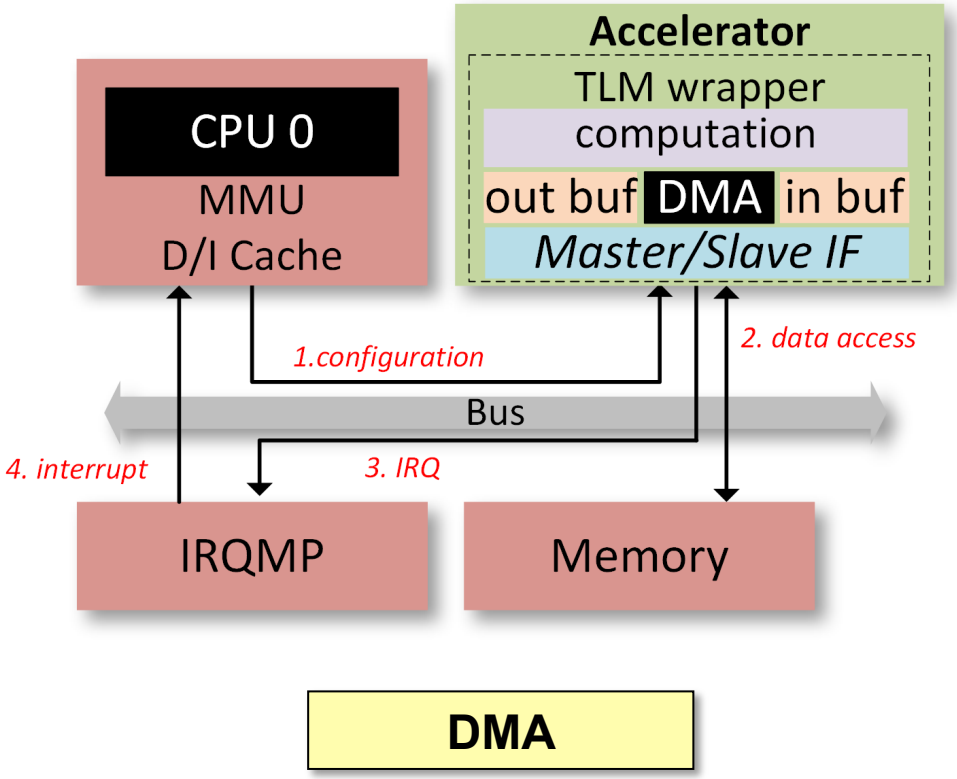
Baseline SoC architecture based on SoCRocket IPs



Accelerator architecture and data flow

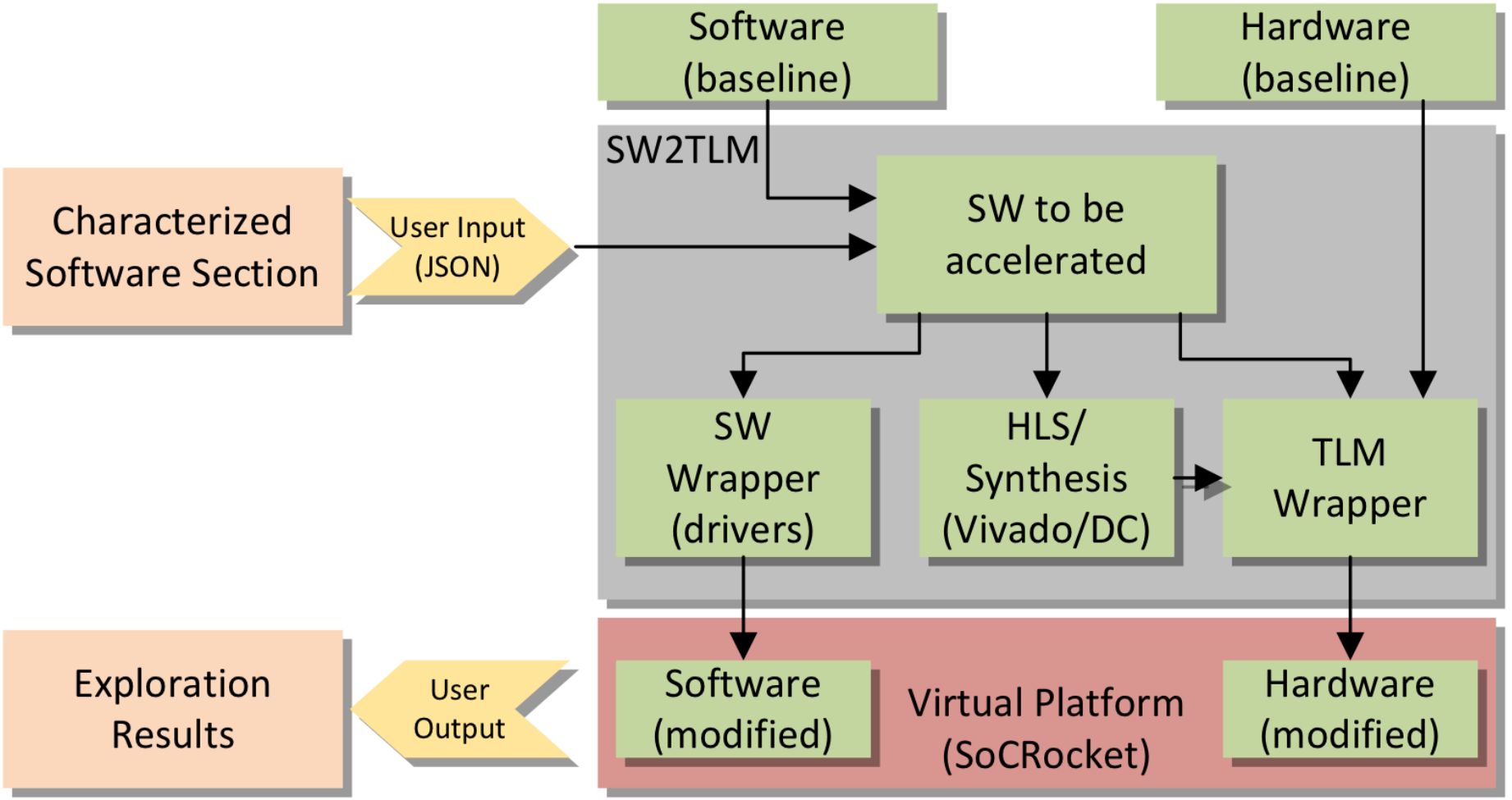


Software



DMA

SW2TLM automated tool chain and user interaction



JSON based characterization of a software function

```
void dct(signed char pixels[8][8], int color, signed short dctresult[8][8] )
```

```
"conf": {
  "file_name": "dct.c",
  "function_name": "dct",
  "defines":header.h,
  "irq_en":true,
  "dma_en“:false},
```

```
"input": {
  "pram1":{
    "vname":"pixels",
    "typ":"signed char",
    "len":"8*8” },
  "pram2":{
    "vname":"color",
    "typ":"int",
    "len":"1” }},
```

```
"output": {
  "pram1":{
    "vname":"dctresult",
    "typ":"signed short",
    "len":"8x8”  }}
```

Performance analysis parameters

Parameter Name	Description
$t_{receive}$	Writing data to HW ACC directly or via DMA
$t_{transmit}$	Reading data from HW ACC directly or via DMA
t_{decode}	Decoded data in ACC
t_{encode}	Encode data in ACC
$t_{computation}$	HW ACC computation time
$t_{com-overhead}$	Communication overhead
t_{acc_total}	Total HW ACC execution time
t_{sw}	Execution time in of selected software section
t_{app}	Absolute application execution time

$$t_{acc\_total} = t_{receive} + t_{decode} + t_{computation} + t_{encode} + t_{transmit}$$

Performance analysis parameters

Parameter Name	Description
$p_{leakage}$	Static power consumption
$p_{internal}$	Internal part of dynamic power consumption
$p_{switching}$	Switching part of dynamic power consumption
p_{total}	Total power consumption
e_{total}	Total energy consumption

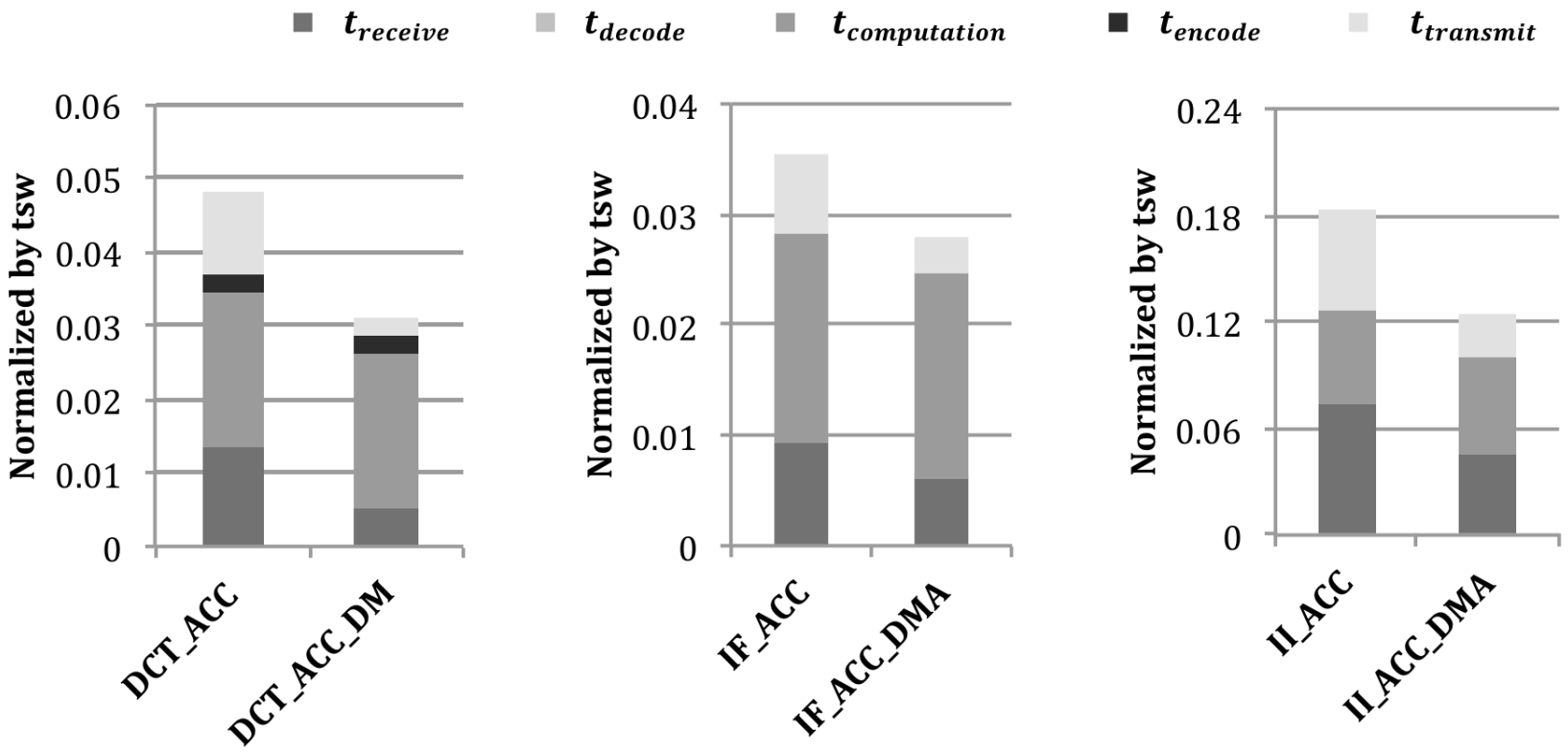
$$P_{total} = P_{leakage} + P_{internal} + P_{switching}$$

$$e_{total} = P_{total} * t_{app}$$

Test Applications

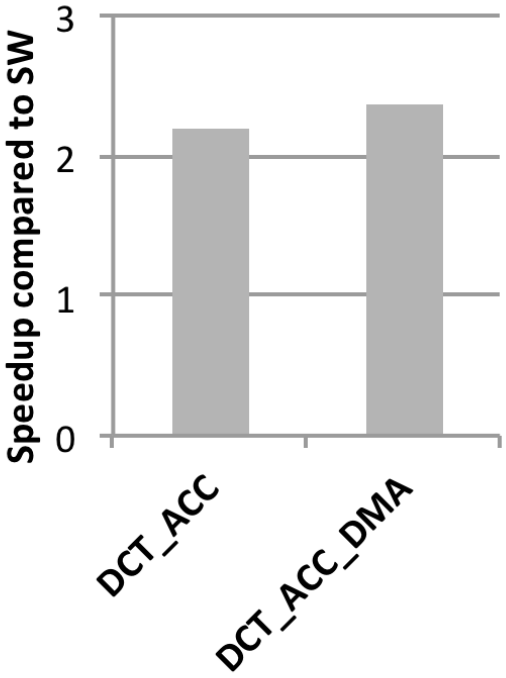
Discrete Cosine Transformation (DCT)	The main part of JPEG encoder
Image Filtering (IF)	A low pass FIR filter commonly used for reducing the noise in an image
Image Integration (II)	Used in computer vision algorithms for image pyramid implementation

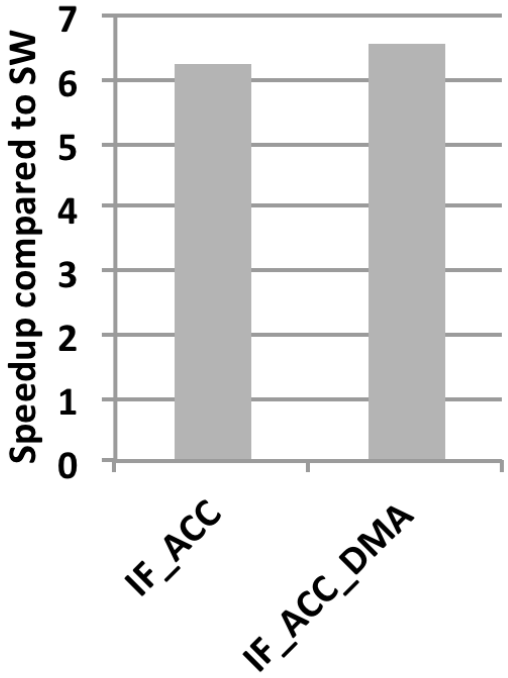
Combined accelerator delays

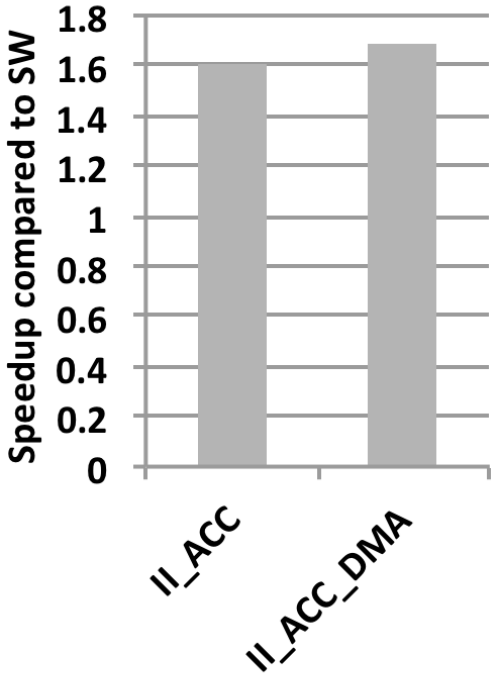


The overhead introduced by decoding, encoding and transmission can account for up to 70% of the overall accelerator delay (image integration)

Absolut application speed up



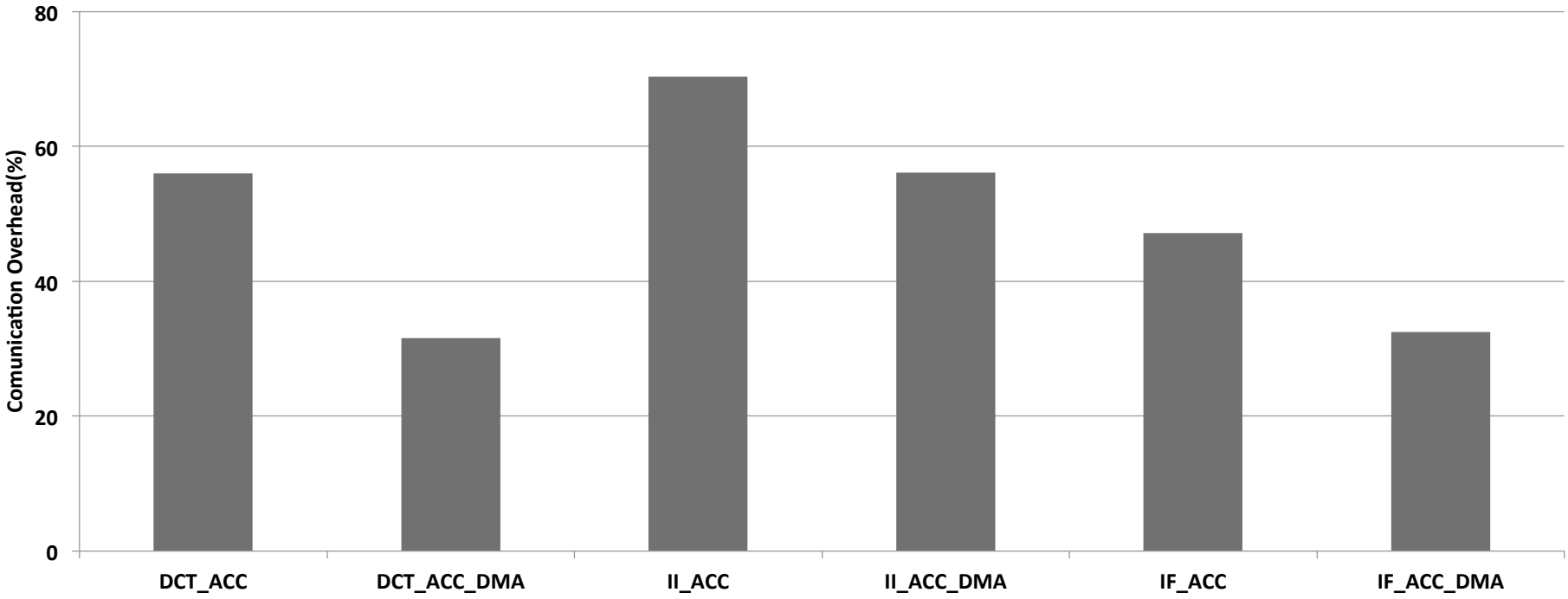




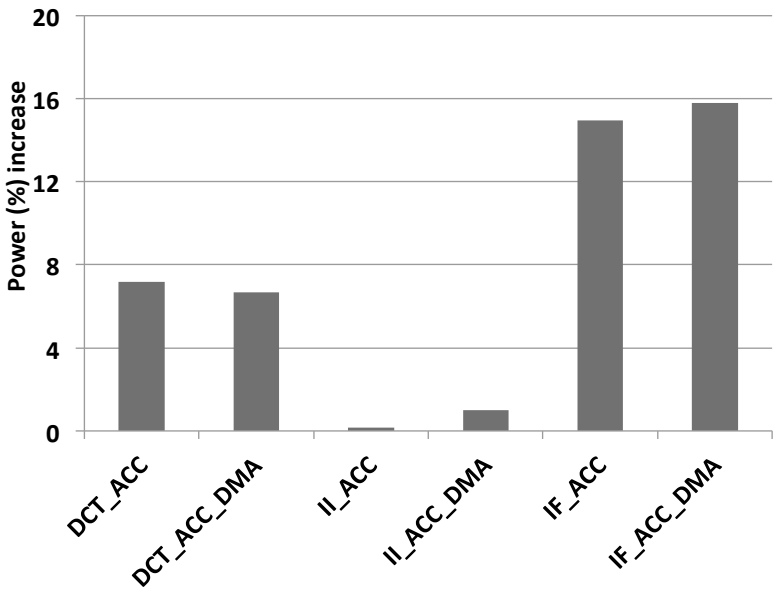
Highest speedup is achieved for computational complex image filtering (up to 6.5x)

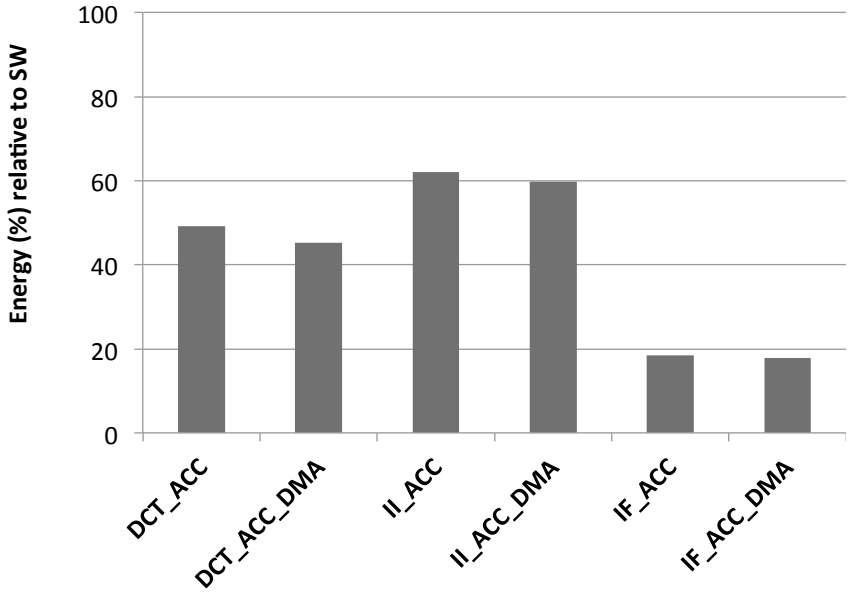
Communication overhead

$$Co_t = \frac{t_{receive} + t_{decode} + t_{encode} + t_{transmit}}{t_{acc\_total}}$$



Power & Energy consumption relative to SW





- As the TL model of the ISS does not incorporate idle power states, the average power consumption is increased by the accelerator
- Despite this limitation, the overall energy consumption is still significantly improved (between 18% and 62%)

Summary

- Automatic and fast framework for complex hardware/software systems
- Real world image processing demonstrator
- Improved engineering support for difficult DSE
- TL accelerator generation based on minimal user input
- Realistic performance, power and communication overhead analysis is performed using a state of the art virtual platform
  - Analyzing communication is of high importance (up to 70% of the computational delay)
  - Early analysis of energy consumption is critical for battery dependent systems

SoCRocket is available online: https://socrocket.github.io/

For more information do not hesitate to contact us!

Questions ?