

# **Identifying compiler options to minimize energy consumption by embedded programs**

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GCC Cauldron, Prague, 9 July 2012

- FLOSS software house developing *embedded* SW tools
  - GNU and (soon) LLVM tool chains
  - Hardware simulation (Verilator and Icarus Verilog)
- Founded 2008
  - UK HQ
  - 4 staff
  - Joern Rennecke leads GCC work
  - Jeremy Bennett leads GDB and HW modeling work
- GCC interests
  - Adapteva Epiphany
  - Synopsys ARC600/700
  - OpenRISC 1000
  - MILEPOST



## Ericsson T65

- released 2001
- Li-Ion 720 mAh
- standby 300 h
- talk time 11 h
- includes talk/standby prediction



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## Sony Ericsson Xperia X10 mini

- released 2010
- Li-polymer 930 mAh
- standby up to 285 h (3G) / 360 h (2G)
- talk time up to 4 h (2G) / 3.5 h (3G)


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## Free mobile apps 'drain battery faster'

**Free mobile apps which use third-party services to display advertising consume considerably more battery life, a new study suggests.**

Researchers used a special tool to monitor energy use by several apps on Android and Windows Mobile handsets.

**Findings suggested** that in one case 75% of an app's energy consumption was spent on powering advertisements.

Report author Abhinav Pathak said app makers must take energy optimisation more seriously.



Like many games, Angry Birds has a free version supported by targeted advertising

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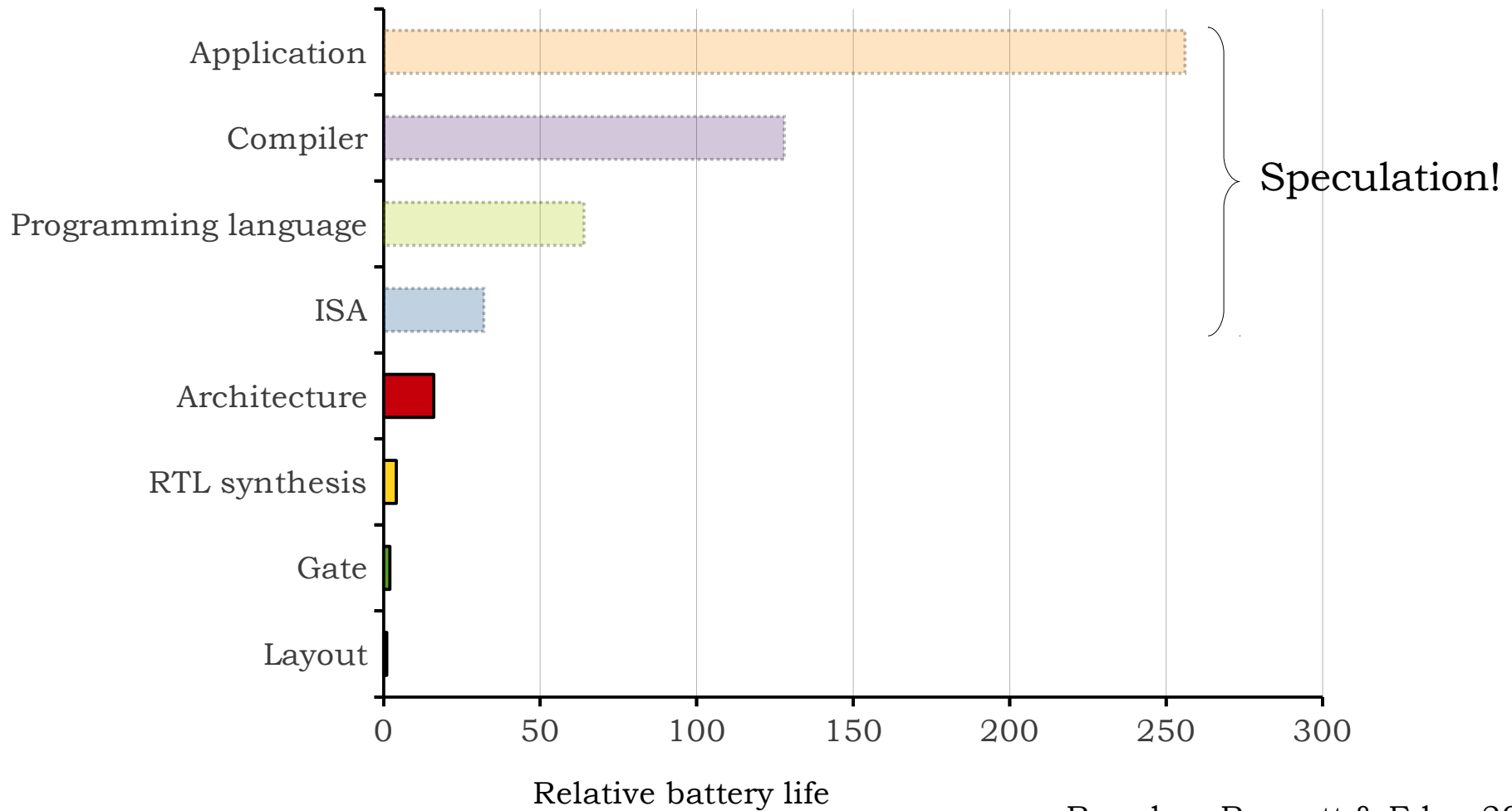
### Features & Analysis



**Shock n' Roll**  
Why world's first rock concert ended in chaos



**Spring quiz**



Based on Bennett & Eder, 2011

- Largely in the realm of hardware engineering
- Hardware design aims to minimize
  - static (leakage) power loss
  - dynamic (switching) power loss
- Techniques used
  - dynamic voltage and frequency scaling (DVFS)
  - multiple mode operation (standby, sleep, suspend, off)
- Scope for savings
  - $P = V^2R$
  - on-chip voltage can range from  $\sim 0.5V$  to  $\sim 1.5V$
  - lower frequencies mean lower voltages can be used
    - win on both static and dynamic power loss
- Is this where the greatest savings can be made?

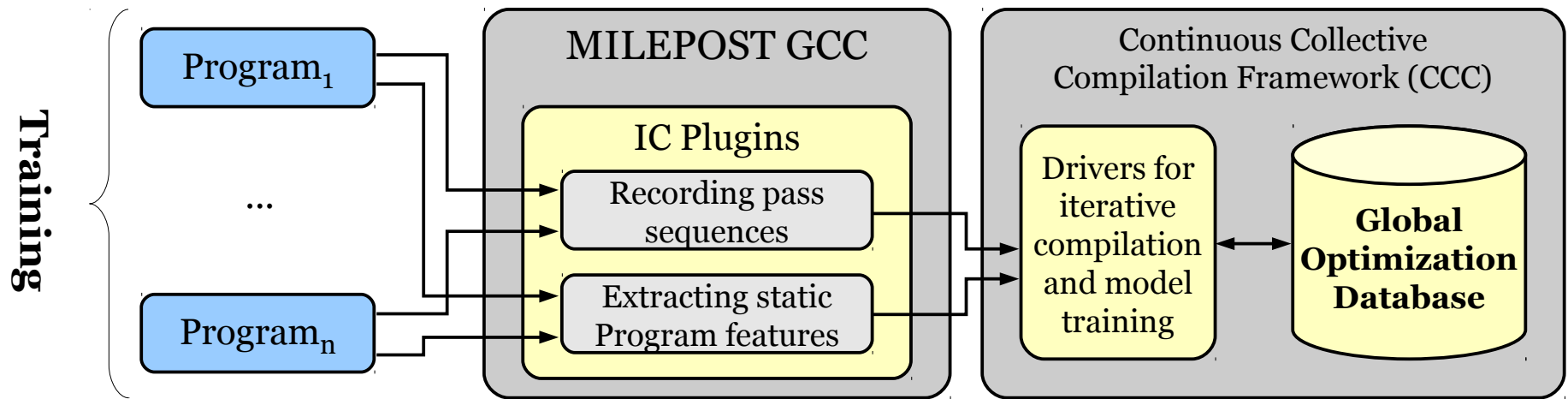
- Software controls the hardware
  - algorithms and data flow
  - compiler optimization traditionally speed or size as objective
- Few software engineers appreciate this
  - how does an algorithm affect the power consumption?
  - power consumption is often a secondary design criterion in software
- Yet biggest savings are at the higher levels of abstraction
  - choice of algorithm
  - data handling
  - instruction set architecture and compiler
- Why?
  - energy is consumed by the hardware computations
  - but ultimate control of that hardware lies with the software



Kaushik Roy and Mark C. Johnson. 1997. Software design for low power. In *Low power design in deep submicron electronics*, Wolfgang Nebel and Jean Mermet (Eds.). Kluwer Nato Advanced Science Institutes Series, Vol. 337. Kluwer Academic Publishers, Norwell, MA, USA, pp 433-460.

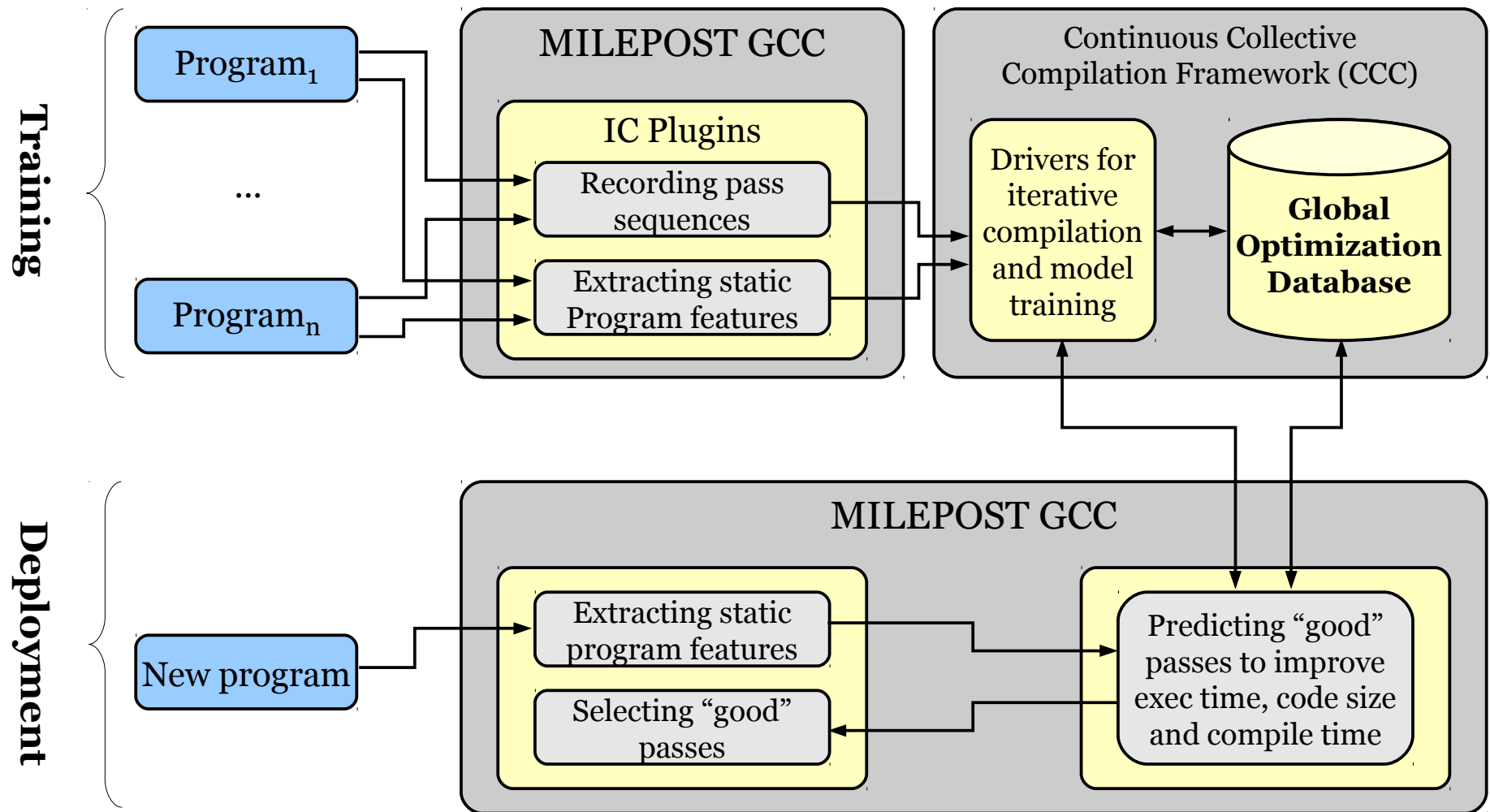
- Choose the best algorithm to fit the hardware
- Tune algorithms to manage memory size and memory access
- Optimize for performance, making best use of parallelism
- Use hardware support for power management
- Minimize CPU and data path switching in the generated code

- Is the compiler a good place to seek energy saving?
  - how influential are compiler options?
- No one knows!
  - lots of speculation, little experimental data
- Our project, July-Oct 2012 with Bristol University & EACO
  - measure energy consumption by a representative set of programs
    - what set?
  - do compiler options have any impact?
    - is optimizing for speed the same as optimizing for power
  - does choice of compiler (GCC, LLVM) make a difference?
  - does architecture (XMOS, ARM, Epiphany) make a difference?
- Your help is needed...



- EU funded research project completed in 2009
  - aim to achieve similar results to full **Iterative Compilation**
- This could be ideal for energy minimization

*From Fursin et al, 2008*



*From Fursin et al, 2008*

# Thank You

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