hyperC: An Energy-Aware RTOS for IoT Devices

Ting-Chang Huang
National Chiao Tung University

Po-Hung Chen
SOCWare.net

Yoshi Shih-Chieh Huang
National Tsing Hua University

Ta-Wei Lin
SOCWare.net

Abstract

Battery lifetime is critical to the connectivity of battery-powered Internet-of-Things (IoT) devices. In this poster, an energy-aware real-time operating system, hyperC, is presented for extending battery lifetime of battery-powered IoT devices. The energy awareness of hyperC comes from introducing modern power management schemes and utilizing acceleration functions of modern SoCs for IoT. For the power management schemes, dynamic frequency scaling and tickless software timer are included in hyperC. In running state, the former can reduce the energy consumption of CPUs by adequate proper frequency. The latter can extend CPU idle time by preventing idling CPUs from unnecessary interrupts. In addition, since floating point is frequently used in sensor-based IoT devices, hyperC adopts hardware-assisted lazy float context switch which is able to reduce power consumption and improve performance when context switch occurs.

Currently, hyperC is optimized for CortexM-based IoT devices and supports modern IoT protocols (e.g. AWS IoT and CoAP). Although additional power management schemes are included, hyperC still has small memory footprint (< 9KBytes). Compared with FreeRTOS running on the same devices, hyperC can reduce standby power by 13.4% and reduce context switch time by up to 58%, respectively. In addition, hyperC provides higher network throughput by up to 20%

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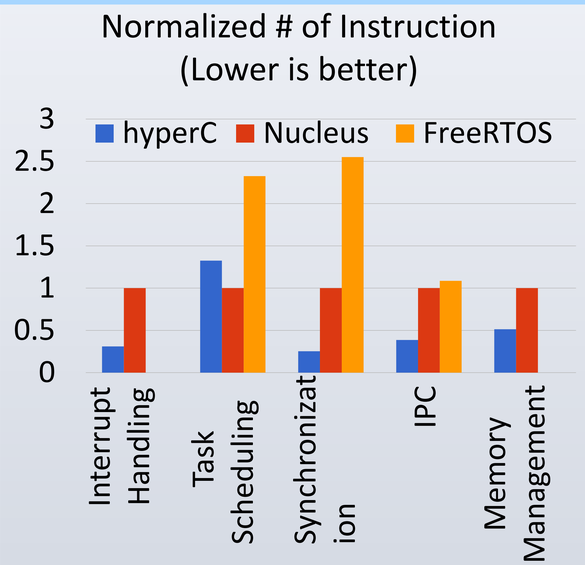
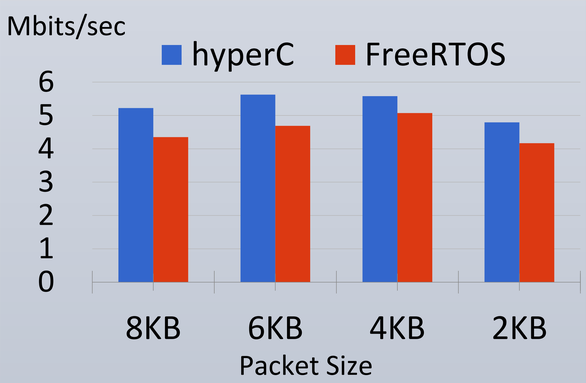
Evaluation

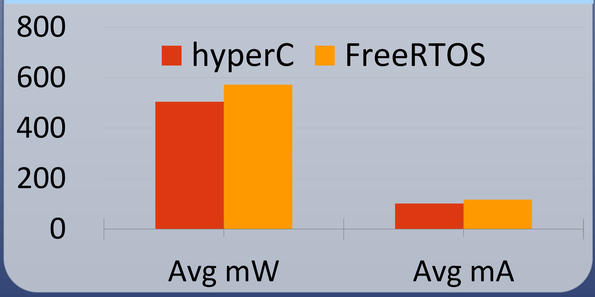
Overhead Comparison



Network Throughput (iperf)



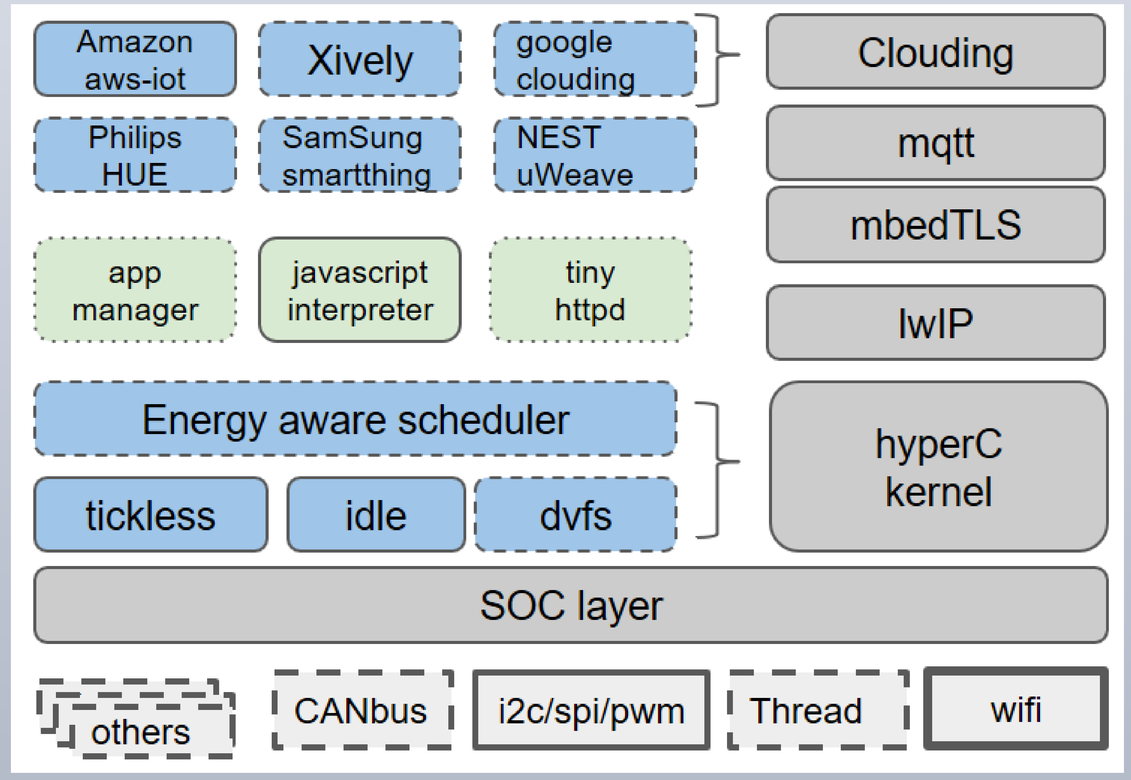
Power/Energy Consumption



Summary

- hyperC = An OS for battery-powered IoT devices
- Energy-awareness features:
  - Dynamic frequency scaling (DFS)
  - Tickless software timer
  - Hardware-assisted Lazy float context switch
- Compared with FreeRTOS, hyperC achieves:
  - Higher network throughput by up to 20%
  - Lower standby power by up to 13.4%
  - Faster context-switching by up to 58%
- Portability
  - Currently ported to MT7687 (MediaTek) & STM32F407 (ST)

System Overview



Feature Comparison

	hyperC	Nucleus	FreeRTOS
IRQ-nested	Y	Y	
Fast IRQ	Y		
Priority inheritance	Y		Y
System utilization profiling	Y	Y	
Loadable module	Y		
Static size memory pool	Y	Y	
Hardware support bitmap manipulation	Y		
Memory allocation algorithm	O(logn)	O(n)	O(n)
Tickless Idle	Y		Y
Debug tools	Y		
TrustZone™ Support	Y		
ARM MMU support	v5, v7		
ARM Cortex-support	A, R, M	A, R	R, M
Lazy float context switch	Y		
IPv4,v6	Y		Y
TCP/UDP	Y		Y
AWS IoT support	Y		
Emulation suite	Y		

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