

# An Introduction to the Operating Systems of the IoT

Elahe Jalalpoor and Parham Alvani

Amirkabir University of Technology

`elahejalalpoor@gmail.com`

`parham.alvani@gmail.com`

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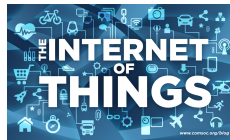


## What is IoT...

The Internet of Things (IoT) is a scenario in which objects, animals or people are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.

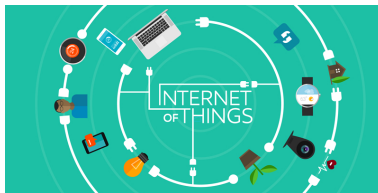
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# Open Source Operating Systems for the IoT

- ▶ FreeRTOS
- ▶ RIOT
- ▶ Contiki
- ▶ TinyOS
- ▶ Embedded Linux
- ▶ OpenWSN



# FreeRTOS

- ▶ FreeRTOS is designed to be **small** and **simple**.
- ▶ The kernel itself consists of only three or four C files.
- ▶ It provides methods for multiple threads or tasks, mutexes, semaphores and software timers.
- ▶ Key features are **very small memory footprint**, **low overhead**, and **very fast execution**.



- ▶ RIOT is a **real-time multi-threading** operating system.
- ▶ RIOT is based on design objectives including:
  - Energy-Efficiency
  - Reliability
  - Real-Time Capabilities
  - Small Memory Footprint
  - Modularity
  - Uniform API Access
    - independent of the underlying hardware
    - (this API offers partial POSIX compliance)



- ▶ Contiki is an open source operating system for **networked**, **memory-constrained** systems
- ▶ Contiki provides three network mechanisms:
  - The uIP stack, which provides IPv4 networking,
  - The uIPv6 stack, which provides IPv6 networking,
  - The Rime stack, which is a set of custom lightweight networking protocols designed specifically for low-power wireless networks.

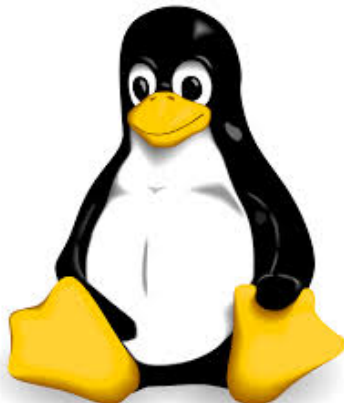


- ▶ TinyOS is a **component-based** operating system and platform targeting wireless sensor networks.
- ▶ TinyOS is an embedded operating system written in the **nesC programming language** as a set of cooperating tasks and processes.



# Embedded Linux

- ▶ Embedded Linux is created using OpenEmbedded, the build framework for embedded Linux.
- ▶ OpenEmbedded offers a best-in-class cross-compile environment.





- ▶ The goal of the OpenWSN project is to provide open-source implementations of a complete protocol stack based on Internet of Things standards, on a variety of software and hardware platforms.



# Comparison

OS	Min RAW	Min ROM	C Support	C++ Support
Contiki	$< 2kB$	$< 30kB$	Partial support	No support
Tiny OS	$< 1kB$	$< 4kB$	No support	No support
Linux	$\sim 1MB$	$\sim 1MB$	Full support	Full support
RIOT	$\sim 1.5kB$	$\sim 5kB$	Full support	Full support



# Comparison

OS	Multi-Threading	Modularity	Real-Time
Contiki	Partial support	Partial support	Partial support
Tiny OS	Partial support	No support	No support
Linux	Full support	Partial support	Partial support
RIOT	Full support	Full support	Full support



# Why Not Linux?

## Real-Time Linux

Controlling a laser with Linux is crazy, but everyone in this room is crazy in his own way. So if you want to use Linux to control an industrial welding laser, I have no problem with your using PREEMPT\_RT.

- Linus Torvalds



# Why Not Linux?

- ▶ Linux certainly is a robust, developer-friendly OS
- ▶ Linux has a disadvantage when compared to a real-time operating system:
  - Memory footprint
  - It simply will not run on 8 or 16-bit MCUs



# Internet Usage and Protocols for the IoT

## **Web** Hundreds / thousands of bytes



- Inefficient content encoding
- Huge overhead, difficult parsing
- Requires full Internet devices

## **Internet of Things** Tens of bytes



- Efficient objects
- Efficient Web
- Optimized IP access

# Questions?