# Linux For Embedded Systems

*For Arabs*

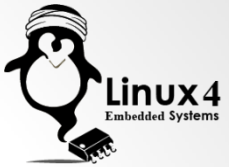
# Course 101:

## Introduction to Embedded Linux

Ahmed ElArabawy

# Lecture 4:

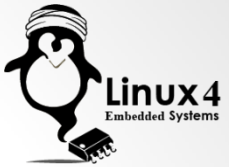
## A Tour in RTOS Land




# PROPRIETARY RTOS'S

# Windows CE






- Developed by Microsoft
- Has recently been replaced by Windows Embedded Compact
- Has the mix of the windows desktop and embedded devices requirements
- Suitable for embedded devices that require also a good user interface
- Medium to Large HW requirements:
  - Footprint of OS around 200-350KB
  - May run in under a 1MB of memory
- True RTOS, has a deterministic behavior
- Cost is around $3 per device license + Initial Cost for tools

# Application Examples


# Nucleus

NUCLEUS

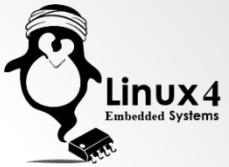
Linux4 Embedded Systems

- Developed by Mentor Graphics
- Portable to different devices (Microcontrollers and Micro - Processors)
- Foot print as small as 2KB
- Support unique power management features
  - Power/clock gating
  - Deep sleep modes
- Cost is about
  - $13K for the OS license per implementation
  - $3K per seat for the tools
  - Royalty free

# NUCLEUS Application Examples

- Very widely used

# Threadx


- Developed by Express Logic, Inc. by the same the author of Nucleus
- Small footprint ( can go as low as 2KB on Microcontrollers)
- True RTOS, Fast and deterministic behavior
- Fast boot time (This is very important for devices that can't afford a long boot time)
- Flexible licensing models + Royalty free

# Application Example

Hewlett-Packard use ThreadX in all of their printers,

- Inkjets
- LaserJets
- All-in-One

# Application Example

Broadcom use ThreadX in a lot of its Chips for cell phones in their communication processors

# VxWorks

VxWorks®

WIND RIVER

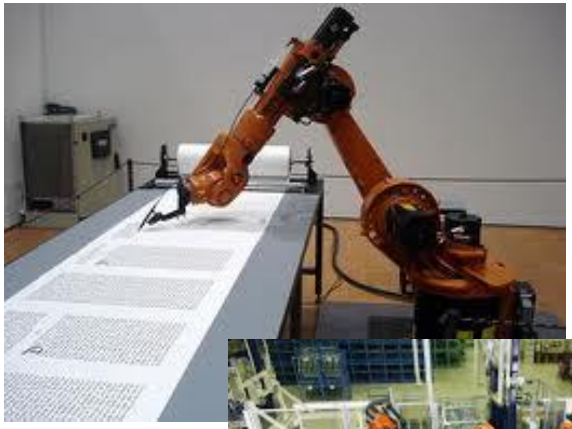
- Developed by Wind River Systems, 1987
- Legacy RTOS. Used to be the top OS for Embedded Platforms
- Not used recently for small system, but still considered by heavy Institutions (such as Aerospace and Defense)
- Expensive licensing cost + Royalty cost
- Other OS's with their latest development are catching up

VxWorks®

WIND RIVER

# Application Example

Linux4 Embedded Systems



KUKA

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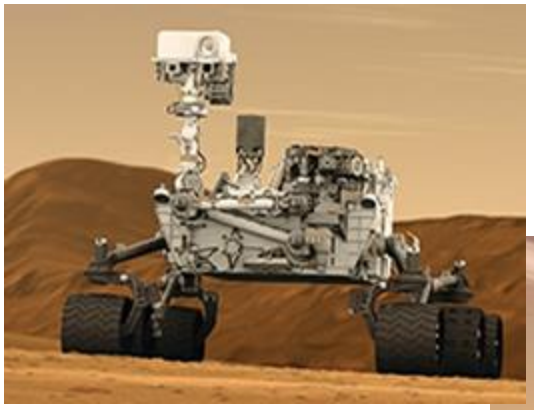
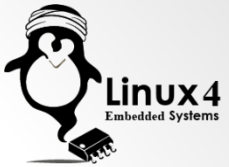
WIND RIVER

# Application Example

Linux4 Embedded Systems



NASA JPL Jet Propulsion Laboratory California Institute of Technology

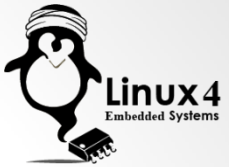



# FREE-OPEN SOURCE OS'S

# Is Free Really Free ??

- Free for freedom and not for free drink
- Free means freedom to run, study, copy, modify, distribute both the original code and the modified versions
- Free/Open source OS's include:
  - The OS itself (the kernel)
  - Development tools: Compilers, Debuggers, toolchains, …
  - Support libraries: C library, XML parsers, Security, command line utilities
- Keep in mind the licensing risks (GPL, LGPL, … )
  - Licensing terms
  - Might mean you can not have a proprietary system
  - Might mean you need to give up your source code

# Advantages of Open Source OS




- Cost perspective
  - Kernel, development tools, associated libraries and support tools, applications, …
- Big community help and support
- Ability to understand and control details of operation
- Availability of online resources and documents
- Fast release cycles
- Ability to influence the future of the OS

# Linux (www.kernel.org )


- Most popular Open Source OS
- Big Community Support
- Distributions
  - Build your own distribution
  - Redhat
  - Suse
  - Ubuntu
  - And many others
- GPL v2.0 License
- Require 32bit processors with MMU
- Highly configurable, RAM and Storage requirements according to configurations
- Not a real RTOS
- Sometimes used with patches to support hard real time embedded applications (such as RTLinux)

# uClinux (www.uclinux.org )


- Started as a port of Linux for systems with,
  - Micro-controllers
  - Processors without MMU
- Used for simple Embedded devices
- Now highly integrated with the Linux mainstream as a patch
- Used in several devices such as,
  - DVD players
  - Security cameras
  - VoIP phones
  - Scanners

# eCos (http://ecos.sourceware.org )


- Suitable for smaller embedded systems
- Small footprint, with low requirement on resources
- Modified GPL License to give developer more rights to use it without need to GPL his code
- One of the most popular open source RTOS in the world today
- Highly configurable (eCos stands for the "Embedded Configurable Operating System")
- Support multi-tasking with priority-based real-time scheduler
- standards based APIs
- True RTOS, Highly deterministic behavior
- Highly portable  to  most of 32 bits processors

# Application Example

Sony, Playstation 3 Gaming Console for WiFi support

# Application Example

Samsung, latest LCD HDTVs (32-70 inch) to support multi-media playback via USB2 from cameras, mp3 players and flash drives

# Application Example

Eye-Fi Wireless SD Cards that use WiFi to transfer images between camera and computer

# Nuttx

- First released by Gregory Nutt in 2007 with BSD license
- True RTOS (deterministic)
- Small footprint
- Supports from simple 8 bit processors (such as Zilog Z80) to 32 bit processors (such as ARM-9, x86)
- Supports C & C++ development
- TCP/IP Stack and USB support
- Support multitasking with FIFO and round-robin scheduling
- Support pre-emption
- Highly configurable
- Supports Standard APIs such as ANSI and POSIX
- Used in MP-3 players, Auto-pilot, …

# Application Example

Linux4 Embedded Systems


# Linux 4 Embedded Systems

http://Linux4EmbeddedSystems.com