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# Embedded Linux

## - Mobile Phones

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# Topics Discussed

- n What's Embedded Linux
- n Developed by whom..
- n Requirements in mobile phone
- n Flavors of OS –Mobile Phone
- n Why go for Embedded Linux
- n What can be drawbacks
- n Tools used for mobile phones
- n Market trends
- n Examples of how to approach some problems in Embedded Linux
- n Introduction to RTLinux and RTAI



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# Embedded Linux

- n **"Embedded" refers to the concept of integrating a computational system (a small computer) into a machine or device, other than an ordinary computer, in order to make such machines smarter and more flexible.**

**Example : a microcontroller programmed for printing purpose**

- n **Linux for products such as mobile phones, PDAs, media player handsets, and other consumer electronic devices is part of "Embedded Linux" .**

**(T)orvolds (U)ni(X) => TUX**



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# Embedded Linux Consortium (ELC)

- n To develop Embedded Linux a consortium was formed on July 15, 2003 by major companies like IBM, Intel, Lynuxworks, Panasonic, Motorola, Samsung, Sharp, Siemens and Sony.
- n They standardized specifications that will help product developers manage power consumption, design user interfaces and achieve real time performance for embedded Linux applications.



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# Requirements – Mobile Phone

## Hardware Requirements

- n **Portable – Devices have to small sized and light weight**
- n **Powered – Recharged with powerful batteries**
- n **Wireless Technologies –Blue tooth**

## Software Requirement (OS Requirements)

- n **Memory size – Increase in memory (RAM/ROM) reflects the production cost  
(compressed file system)**
- n **Stability – System freeze, loss of stored data and other operational interruptions in  
service should be avoided**
- n **Boot time/UI response time – Within user’s stress-free range**
- n **Real time – Processing within constrained time**
- n **Power Consumption – Decreased so that battery life can be extended**



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# Mobile Phone – OS and their vendors

## Different flavors of OS

- n Symbian -- Major Market share
- n Windows Mobile
- n PalmOS
- n Linux

## Vendors :

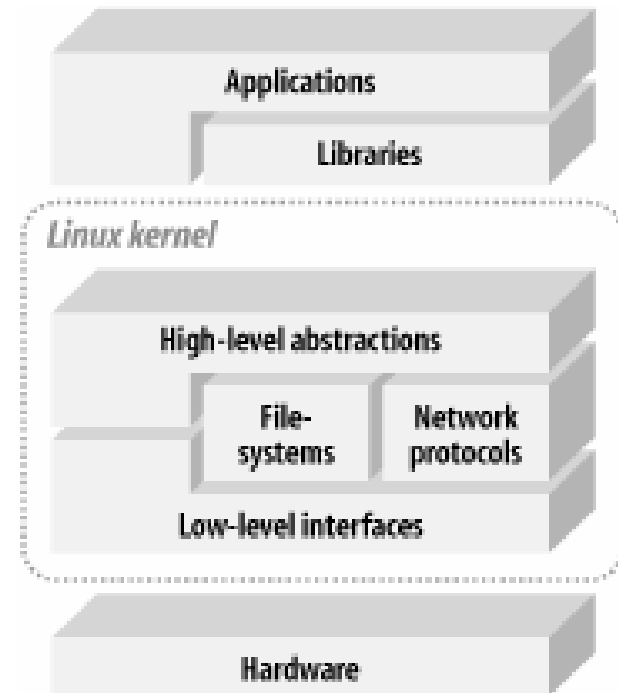
- n Wind River
- n MontaVista
- n Metrowerks
- n FSMLabs
- n TimeSys.
- n LynxWorks



# Advantages of Linux

- n Light weight operating system since requires  
256KB – ROM, 512KB – RAM
- n Open source operating system
- n Simple, monolithic, modular & layered

Architecture of a generic Linux system



Ref:8



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# Advantages of Linux

- n **Customizable:** For instance , Networking and file systems are layered on top of the kernel in a modular fashion. Drivers and other features can be either compiled in or added to the kernel at run-time as loadable modules. This provides a highly modular building-block approach to constructing a custom embeddable system, which typically uses a combination of custom drivers and application programs to provide the added functionality.
- n **Scalable** : More features and applications can be added
- n **Portable** : Can run on many processors having wide ranges of peripheral.
- n **Networking** : internet super-server (inetd), remote administration with SNMP,HTTP
- n **Stable** : Kernel is well developed that it runs for years without crashing.





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# Disadvantage of Linux

- n **Still not completely developed. Users might have to buy drivers from third party vendors if they have to install new hardware => Cost increases even though it has no royalty.**
- n **Expertise in Linux OS is required => Large learning curve involved.**



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# Application - Mobile Phone

- n **A760 - First Handset based on Linux Operating System developed by Motorola**
- n **i250 Intel chip that runs at 200MHz, 2 Flash memory chip with 256MB of memory**
- n **Features**
- n **Digital Camera**
- n **Video Player**
- n **MP3 player**
- n **SpeakerPhone**
- n **Advanced Messaging**
- n **Instant Internet access**
- n **Bluetooth wireless technology**



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## Tools Used in Mobile Phones

- n NEC, Panasonic & Motorola are using MontaVista Linux Consumer Electronics Edition
  - n MontaVista has developed MontaVista Linux Consumer Electronics Edition (CEE), the first commercial Linux operating system and cross-development environment specifically designed for consumer electronics devices, including mobile phones, high definition digital television etc.
  - n CEE enhances Linux with dynamic power management, rich consumer-focused networking support and consumer-grade reliability, while supporting XIP (eXecute In Place) of the kernel and applications as well as streaming media optimizations.
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# Development of MontaVista

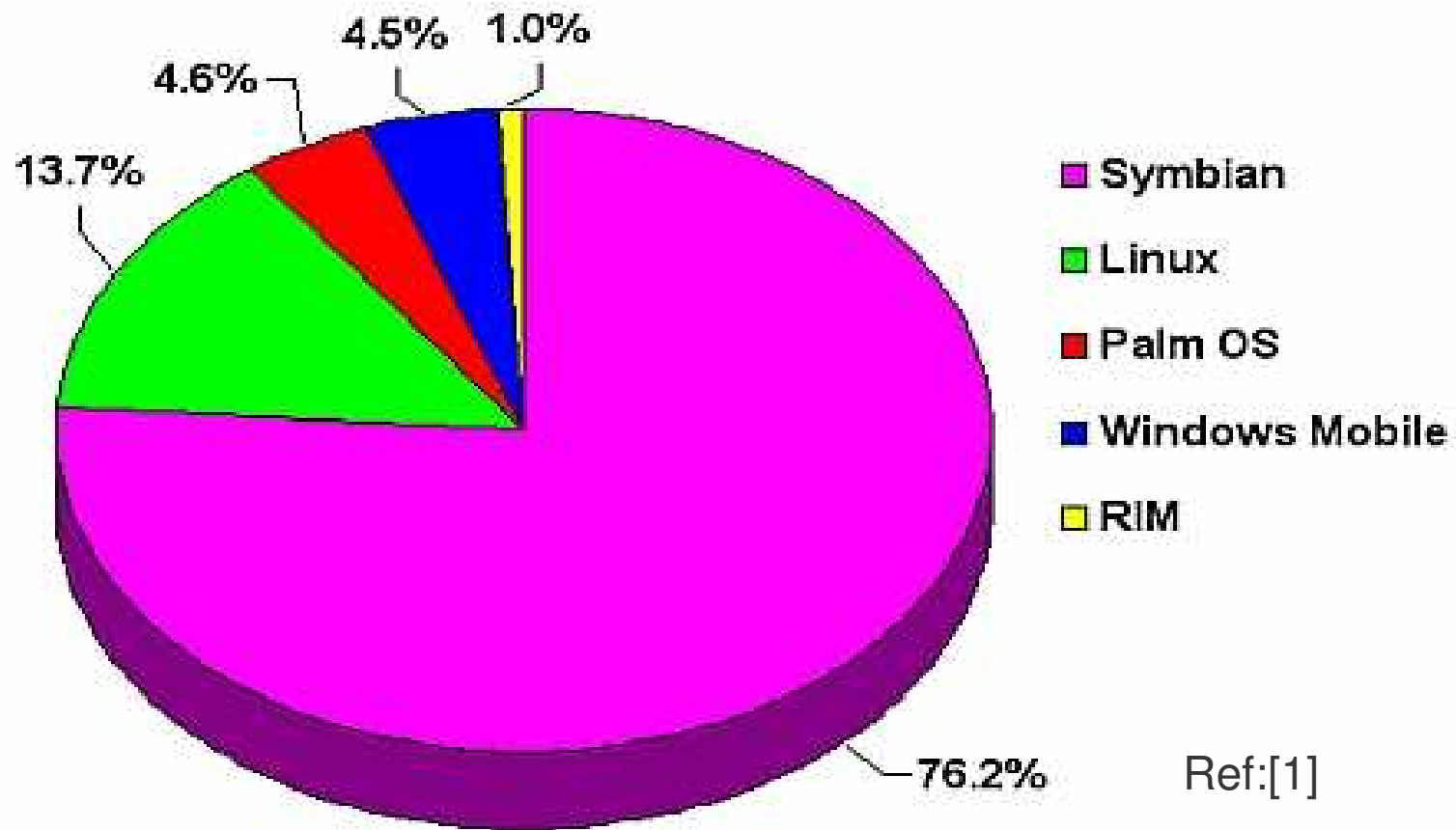
- n Power management : MontaVista is working on dynamic power management methods to improve the ways power is managed on the device.
  - n Processing capability: Co-processor based phones, one processor running a real-time operating system for managing the modem function and on another separate application processor Linux running.
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# Limitations of Linux in Mobile

- n **Embedded linux has to still address power management, lower resource usage, and real-time capabilities to enable less expensive uniprocessor Linux phones**
  - n **Linux has been designed for PC/servers, not devices, which lack the memory, processor, and battery resources required to run the current versions of Linux.**
  - n **Linux is generally regarded as a more complicated and sophisticated operating system compared with the more intuitive "user friendly" operating systems such as PalmOS and Microsoft's PocketPC.**
  - n **Unlike PalmOS and PocketPC, no single company supports mobile Linux, so there is no singular, uniform standard for hardware developers.**
  - n **Linux needs to get better at real-time performance**
  - n **Small form factor imposes limitations on battery life and processing power**
  - n **Still insufficient tool support**
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# Market Trends of OS in Smartphones



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# Approach using Embedded Linux

n **Problem – Memory size**

a. **Many application running parallel - RAM needed will be more.**

n **Solution**

a. **On demand (memory and lib files needed for application)- Multiple application**

b. **Executable binaries (application code in low level language) are usually loaded in RAM directly**

c. **Instead load the executable binaries in ROM (- cramfs file)**

**=> Eliminating copy to RAM, reducing usage of RAM**

***=> Linux kernel has well-defined modules that allow the user to customize according to his requirements***



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# Approach using Embedded Linux

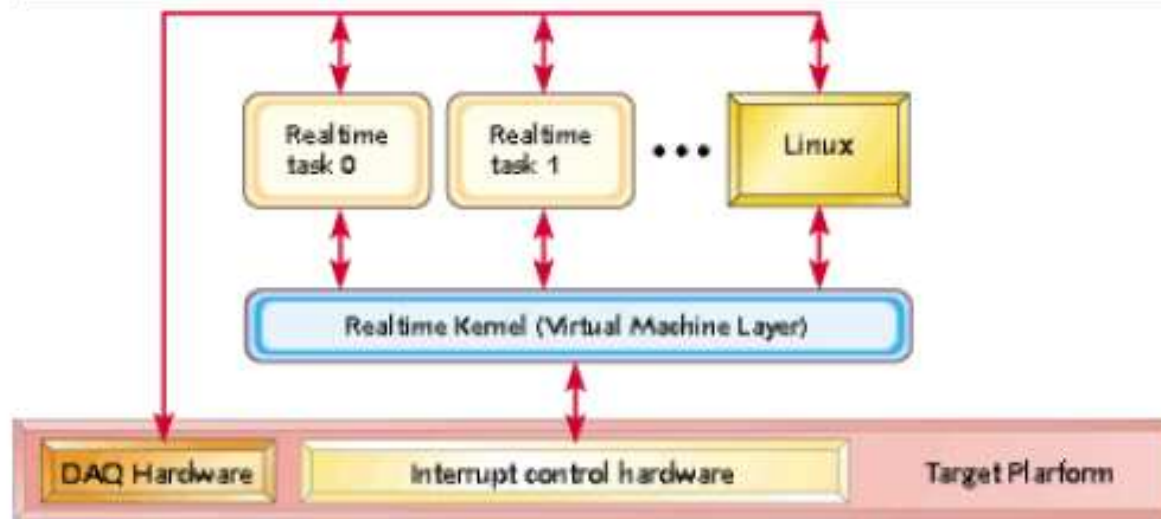
- n Problem – Stability
- n **Shortage of available memory – System freezes or reset (not permissible in mobiles)**
- n Solution
  - a. **Memory usage function that accurately estimates the available memory size was developed**
  - b. **When user tries to activate a new application, the function first**
  - c. **Estimates the available memory and then if there is no enough memory, “memory alert” window pops up to refrain from activating the application.**





# Introduction to RTLinux and RTAI

**Figure 1: Real-time Linux executes real-time tasks**



Ref:[10]

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# RTLinux vs RTAI

- n RTLinux applies most changes directly to the kernel source files, resulting in modifications and additions to numerous Linux kernel source files. Hence, it increases the intrusion on the Linux kernel source files, which can then result in increased code maintenance. It also makes tracking kernel updates or changes and finding bugs far more difficult.
  - n RTAI limits the changes to the standard Linux kernel by adding a hardware abstraction layer (HAL) comprised of a structure of pointers to the interrupt vectors, and the interrupt enable/disable functions. The HAL is implemented by modifying fewer than 20 lines of existing code, and by adding about 50 lines of new code. This approach minimizes the intrusion on the standard Linux kernel and localizes the interrupt handling and emulation code, which is a far more elegant approach.
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# References

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  - n [10]: <http://www.coe.uncc.edu/~jmconrad/ECGR6090-2004-01/notes/linux.pdf>
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Questions ?

Thank you.

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