

State of Mobile Linux

Juha-Matti Liukkonen, Jan 5, 2011

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- Why is this interesting in a Qt course?
- Mobile devices vs. desktop/server systems
- Android, Maemo, and MeeGo today

- Designing software for mobile environments

Why is this interesting in a Qt course?

Rationale

- Advances in technology make computers mobile

- Low-power processors, displays, wireless network chipsets, ...

iSuppli, Dec 2008

- Laptops outsell desktop computers
- High-end smartphones = mobile computers

Nokia terminology

- Need to know how to make software function well in a mobile device

- Qt is big part of Symbian & Maemo/MeeGo API



Developing software for mobiles

- Android smartphones
 - Eclipse, Java
- Symbian smartphones
 - NetBeans / Eclipse, Java ME
 - Qt Creator, C/C++
- Maemo / MeeGo smartphones
 - Qt Creator, C/C++

In desktop/server computing:

Java ::= server

C/C++ ::= desktop

Qt was initially developed for desktop applications.

Mobile devices today are more powerful than the desktops 10 years ago.

Of particular interest in this course.

The elephant in the room

- In 2007, Apple change the mobile world with the iPhone
 - Touch user interface, excellent developer tools, seamless services integration, ...
 - Modern operating system, shared with iPod and Mac product lines
 - Caught “industry regulars” with their pants down
 - Nokia, Google, Samsung, et al – what choice do they have? Linux!



We don't talk about the iPhone here.

iPad “killed the netbook”

- In 2010, Apple introduced another mobile game changer
 - iPad = basically, a scaled-up iPhone with a 10” touch screen
 - Bigger case = can fit bigger battery, for ~10 hours of intensive use
 - 7,5 million sold as of Sep 30, 2010
 - Phenomenal netbook sales growth fizzled

Apple, 2010

NPD, Morgan Stanley
Research, 2010



App ecosystems

- Powerful mobile computers can run variety of software

- Dynamic availability of applications to provide added value over device lifetime
- Devices become multi-purpose and adaptable
- Voice call functionality a secondary feature



- New software design challenges

- New user interaction models
- Preservation of battery

Nokia was ahead of its time with the Communicator concept back in 1996.

Mobile device constraints

- Mobility = situations change

- May lose network coverage
- May run out of battery

Network connections error out.
Your app dies while writing to a file.
Your app is frozen to let a call through.

- Software needs to adapt to situation at hand

- Mobility = limited resources

- CPUs, GPUs not as fast as on desktop systems
- Smaller screens, different input devices
- Limited amount of battery power

Cross development

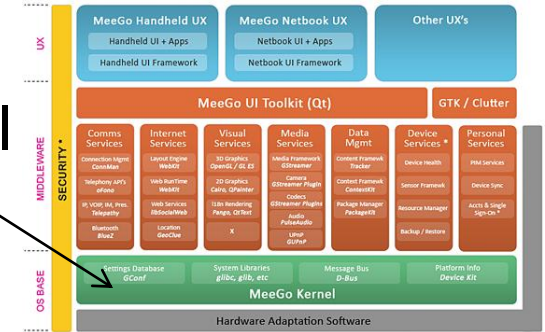
- Cannot compile software in the target device
 - Not enough memory, disk space, CPU power
 - Poor input/output devices for development
- Must use a cross-compile environment
 - SDK = Software Development Kit
 - Build software in e.g. QtCreator, compile with SDK tools, install & run in the target device

Debugging software in target is often a bit tricky. Most SDKs come with a device emulator.

Mobile Linux distributions

Linux Distribution

- Linux is the operating system kernel
 - Deals with hardware abstraction
- A *distribution* is a managed collection of software, including the kernel
 - Device drivers, middleware, user applications
 - Comes with distributor-defined default settings and applications
 - Often optimized for specific use(s)
 - E.g. Ubuntu, Red Hat Enterprise Linux, Maemo



Mobile Linux distributions

- Maemo

- Nokia's Linux distribution for Internet tablets and high-end smartphones
- Powers the N770, N800, N810, N900



- Android

- Google's Linux distribution for Internet tablets and smartphones
- Powers many HTC devices, Nexus One, etc.



Mobile Linux distributions

- OpenEmbedded

- Open source project
- Best suited for custom adaptations to very small devices



- MeeGo

- New kid on the block
- Combines Intel's Moblin netbook Linux and Nokia's Maemo Linux
- First MeeGo devices out in fall 2010



Android details



- Uses custom Linux kernel
 - Google maintains a set of Android patches

- Applications developed using Java

- Google's custom Dalvik Java VM

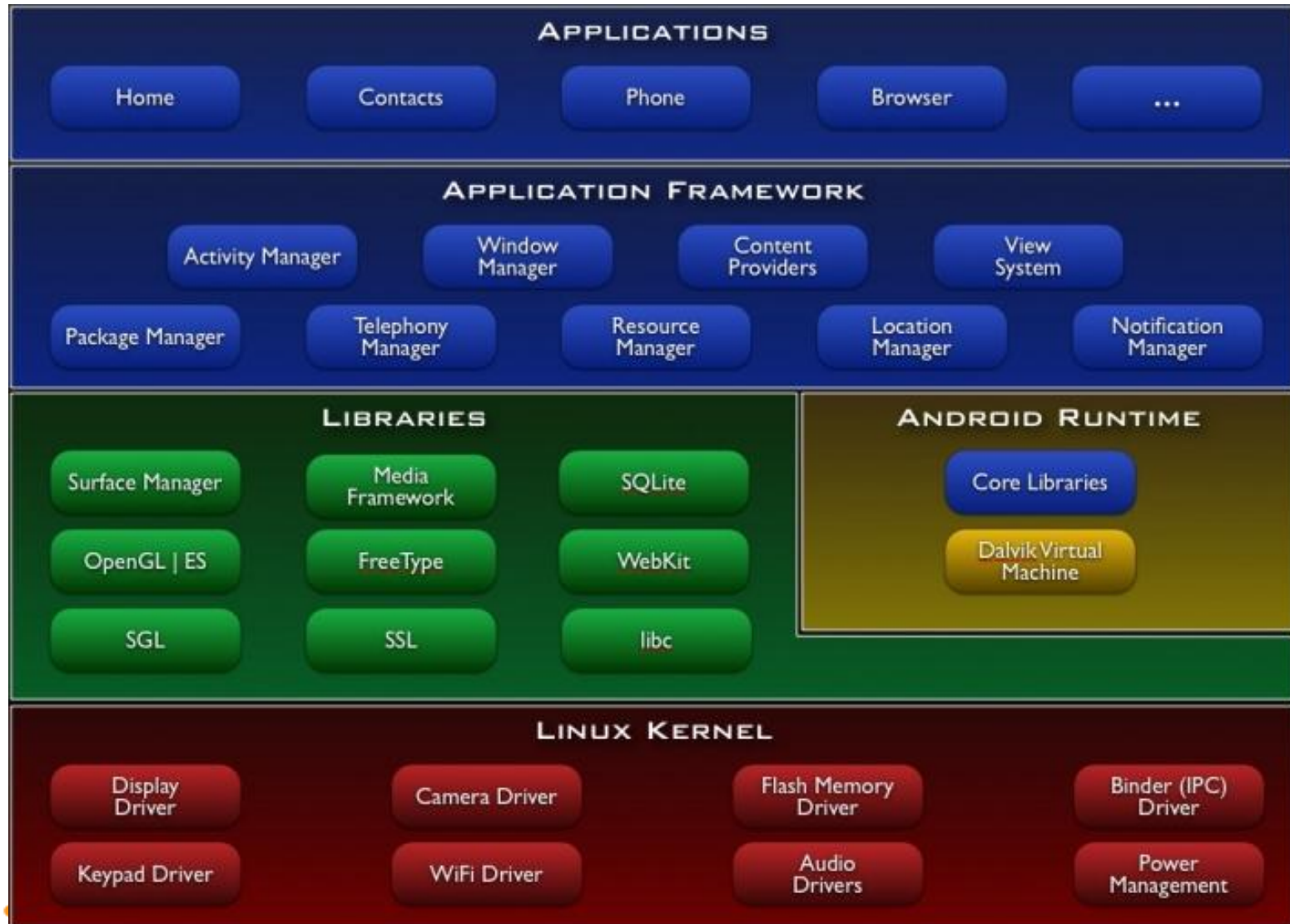
There is also a Native Development Kit (NDK) for building native Linux applications.

- 6 versions in active use

- 1.5, 1.6, 2.0, 2.1, 2.2 and now 2.3
 - Used in various smartphones by HTC, Google, Motorola, LG, etc.

The devices have a bit different resolutions and feature sets.

Android architecture



Android points of interest

- Custom C library
 - C library = system calls (interface to kernel), POSIX & ANSI standard library routines
 - Linux standard is glibc, which is a bit bloated
 - Android has a stripped down libc
 - Compatibility issues for generic Linux code
- Custom application installation
 - Apps bundled into .apk "Android packages"

Android points of interest

- Programming model
 - Activity
 - Implements an application view
 - Service
 - Background program with no UI
 - Broadcast receiver
 - Listens for e.g. battery notifications
 - Content provider
 - Shares data from an app

Android and Qt

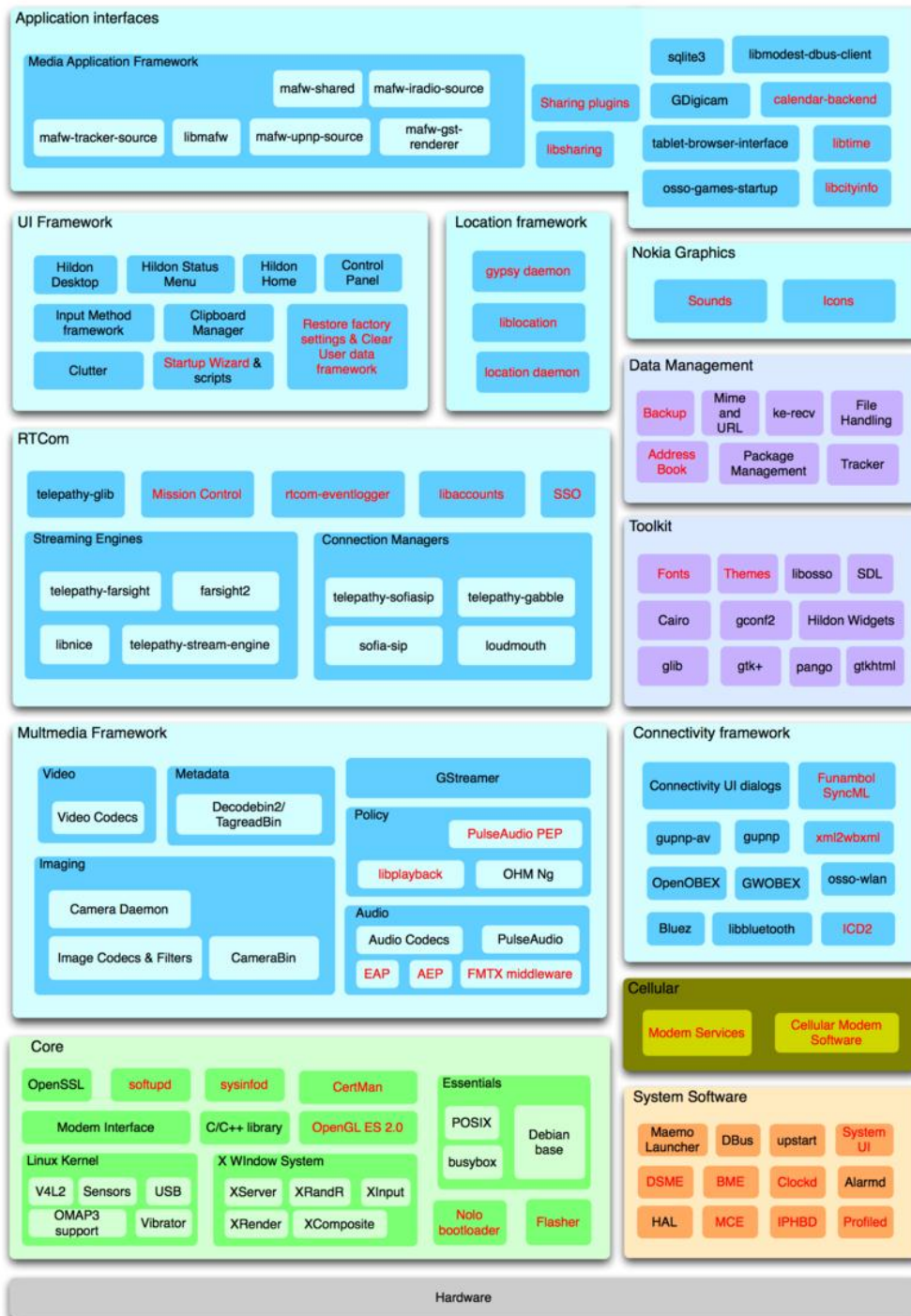
- Project Lighthouse = Qt for Android
 - Project ongoing... not ready for prime time yet
 - Some limitations of Android Native SDK (NDK) cause problems
 - Should eventually allow Qt to be the universal (mobile) Linux toolkit!
 - Google is not very supportive ;-)

Maemo details



- Uses standard Linux kernel
- Applications developed using Qt, C/C++
 - Maemo 4 & 5 are GTK based, but even there Qt is the recommended development toolkit
- Maemo 4 used in Nokia N800 tablet (deprecated)
- Maemo 5 used in Nokia N900 smartphone
- Maemo 6 this fall -> MeeGo

Maemo 5 architecture



Maemo points of interest

- Very regular Linux in most ways
 - Debian based, uses dpkg & apt-get
 - Uses glibc, gstreamer, X.org, etc.
- User interface based on Hildon/GTK+
 - Clutter backend for fancy effects
- Qt natively supported
 - Qt apps for Maemo 5 have the Maemo look & feel, support touch input, etc.

Nokia SDK = QtCreator +
SDKs for Symbian/Maemo

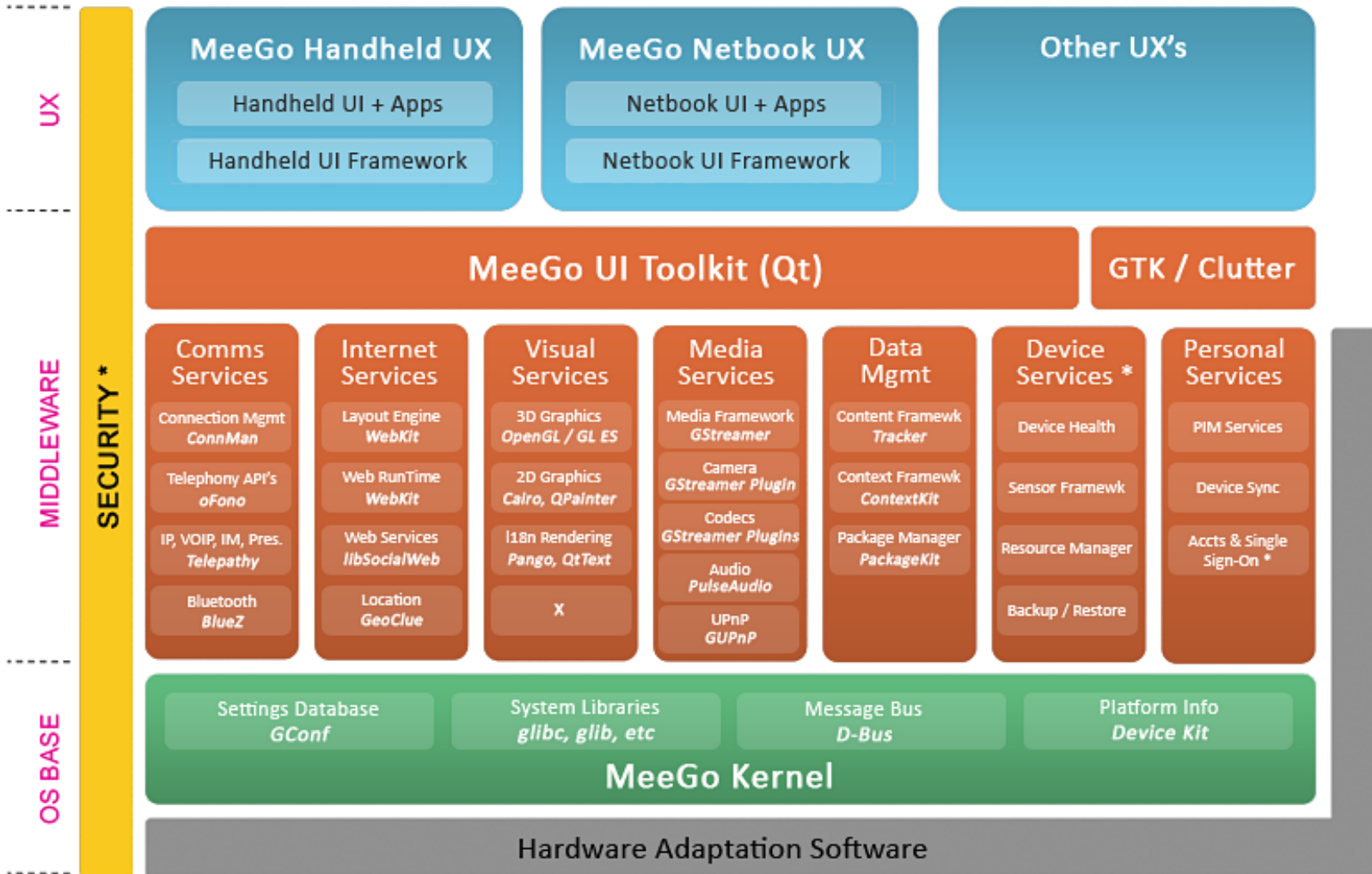
MeeGo details

MeeGo™

< symbio >

- Uses standard Linux kernel
- Applications developed using Qt, C/C++
- Replaces both Moblin from Intel, and Maemo from Nokia
- Some products released already
 - Alpha quality 1.0 release May 2010
 - Beta quality 1.1 release Oct 2010
 - Product quality 1.2 release Apr 2011

MeeGo architecture



MeeGo points of interest

- Mostly regular Linux
 - Glibc, gstreamer, ALSA, etc.
 - Not based on any existing distribution, but uses rpm & zypper for package management
- User interface modules separated from base platform
 - Different user interaction models for different use scenarios
- Qt is the primary application interface

MeeGo points of interest

- UX modules
 - Handheld: touchscreen (meegotouch toolkit on top of Qt)
 - Netbook: keyboard/mouse
 - Connected TV: remote control
 - In-Vehicle Information: touchscreen, joystick
- Reference applications for each UX model
 - System vendors can customize as needed

MeeGo points of interest

- Stable API
 - Any MeeGo application can run on any MeeGo certified system
 - Main part of API is Qt (Core, Gui, Mobility, ...)
 - Also: gstreamer, sqlite, ALSA, D-BUS interfaces to various frameworks, etc.
- Goal is to encourage an App Store ecosystem rivaling Apple

Why MeeGo is interesting to us

- Only credible challenger to Android
- Backed by Nokia -> direct impact to Finnish software development scene
- Innovative architectural solutions
- Aims to become the "industry standard" Linux for modern embedded systems
- Will drive Qt development in mobile space

You can participate in building MeeGo: go to meego.com and become active!

Participate to MeeGo!

- Go to meego.com and register as a developer
 - Participate in community working groups
 - Discuss in #meego at freenode
 - Contribute code, documentation, tests
 - Gain reputation, become a component maintainer
 - Steering group meetings in #meego-meeting
- Help us create the future of mobile Linux!

Developing software for mobile Linux

Software design considerations

- Mobile environment constraints
 - Limited battery power
 - Limited CPU power
 - Limited screen size
 - Changing situations
- Not that difficult to work with, once you know what to avoid
 - Mobile optimized software runs *fast* on higher end hardware

Design your app for a CPU from 1990, graphics from 2005, but use modern tools and techniques.

Limited battery power

- Typical smartphone battery is around 1300-1500 mAh
 - An ARM Cortex A8 @ 600 MHz draws 300 mW - an Intel XEON @ 3 GHz draws 130W
- Software must do as little as possible
 - Must not poll for network traffic, user input, ambient light sensors, ...
 - Must not update the screen when in background
 - Use platform services for notifications

Applications must become *context aware*.

Tools: powertop

```
File Edit View Terminal Go Help
PowerTOP version 1.8 (C) 2007 Intel Corporation

Cn      Avg residency      P-states (frequencies)
C0 (cpu running)  (12.9%)            1.71 Ghz    9.8%
C1      0.0ms ( 0.0%)      1200 Mhz    0.3%
C2      10.7ms (87.1%)     800 Mhz     0.5%
C3      0.0ms ( 0.0%)      600 Mhz     89.4%
C4      0.0ms ( 0.0%)

Wakeups-from-idle per second : 81.2 interval: 15.0s
Power usage (ACPI estimate): 14.1W (6.6 hours) (long term: 136.4W,/0.7h)

Top causes for wakeups:
34.4% ( 31.9) <interrupt> : ipw2200, Intel 82801DB-ICH4, Intel 82801DB-1
19.4% ( 18.0) firefox-bin : futex_wait (hrtimer_wakeup)
15.5% ( 14.4) X : do_setitimer (it_real_fn)
11.5% ( 10.7) evolution : schedule_timeout (process_timeout)
4.3% ( 4.0) <kernel module> : usb_hcd_poll_rh_status (rh_timer_func)
3.9% ( 3.6) <interrupt> : libata
1.8% ( 1.7) <kernel core> : sk_reset_timer (tcp_delack_timer)
1.2% ( 1.1) X : schedule_timeout (process_timeout)
1.1% ( 1.0) Terminal : schedule_timeout (process_timeout)
1.1% ( 1.0) xfce4-panel : schedule_timeout (process_timeout)
0.6% ( 0.5) <kernel module> : neigh_table_init_no_netlink (neigh_periodic
0.5% ( 0.5) spamd : schedule_timeout (process_timeout)
0.5% ( 0.5) events/0 : ipw_gather_stats (delayed_work_timer_fn)
0.4% ( 0.3) xfdesktop : schedule_timeout (process_timeout)
0.4% ( 0.3) firefox-bin : sk_reset_timer (tcp_write_timer)
0.3% ( 0.3) nscd : futex_wait (hrtimer_wakeup)
0.2% ( 0.2) xscreensaver : schedule_timeout (process_timeout)
0.2% ( 0.2) ksnapshot : schedule_timeout (process_timeout)

Suggestion: Disable the unused bluetooth interface with the following command:
hciconfig hci0 down ; rmod hci_usb
Bluetooth is a radio and consumes quite some power, and keeps USB busy as well.

Q - Quit R - Refresh B - Turn Bluetooth off
```

Limited CPU power

- Desktop machines today use 2-4 CPU cores of 2-3 GHz each (4x3 GHz)
 - Server machines have 3-4x that
- Netbooks and smartphones have 1-2 cores of 0.5-1 GHz
 - Level of parallelization is very different
 - Maximum throughput is very different
 - Efficient algorithms work on smartphone level CPUs, and scream on high-end computers



Tools: htop

The screenshot shows the htop interface with the following summary statistics:

- Tasks: 76 total, 1 running
- Load average: 0.00 0.02 0.06
- Uptime: 1 day, 01:19:29
- Mem: 197/499MB
- Swp: 2/511MB

PRI	NI	VIRT	RES	SHR	S	CPU%	MEM%	TIME+	Command
16	0	1440	508	452	S	0.0	0.1	0:00.85	init [2]
14	-4	1424	444	380	S	0.0	0.1	0:00.04	`- udevd
16	0	6016	2828	1596	S	0.0	0.3	0:00.26	`- -zsh
16	0	1424	468	412	S	0.0	0.1	0:00.00	`- /System/Links/Executables/
16	0	1424	468	412	S	0.0	0.1	0:00.00	`- /System/Links/Executables/
16	0	1428	468	412	S	0.0	0.1	0:00.00	`- /System/Links/Executables/
16	0	1428	468	412	S	0.0	0.1	0:00.00	`- /System/Links/Executables/
16	0	5260	1920	1400	S	0.0	0.2	0:00.06	`- -zsh
18	0	2384	1076	904	S	0.0	0.1	0:00.00	`- /bin/sh /System/Links/
16	0	2260	628	540	S	0.0	0.1	0:00.00	`- xinit /Users/hisha
15	0	107M	41764	3804	S	0.7	5.2	11:20.32	`- X :0
16	0	2392	1112	928	S	0.0	0.1	0:00.00	`- /bin/sh /Syste
16	0	1416	316	256	S	0.0	0.0	0:00.00	`- kwrapper k
16	0	32892	14632	7268	S	0.0	1.8	0:02.89	`- kdeinit Running...
16	0	33788	14952	7672	S	0.0	1.8	0:02.46	`- klauncher [kdeinit]
16	0	35852	19008	10576	S	0.0	2.3	0:36.09	`- kwin [kdeinit] -sessio
16	0	38496	21424	12208	S	0.0	2.6	0:15.50	`- konsole [kdeinit]
16	0	6320	3120	1576	S	0.0	0.4	0:00.52	`- /bin/zsh
16	0	6000	2788	1568	S	0.0	0.3	0:00.25	`- /bin/zsh

At the bottom, a legend shows keyboard shortcuts: F1 Help, F2 Setup, F3 Search, F4 Invert, F5 Tree, F6 SortBy, F7 Nice -, F8 Nice +, F9 Kill, F10 Qu.

Limited screen size

- Laptops may have 17", 1920x1200 screens
 - Netbooks have 7-13", max 1280x800
 - Smartphones have 3-4", max 860x480
- Designing a scaling application UI is hard
 - Dialogs designed for 860x480 may look tiny on 1920x1200
 - Dialogs designed for 1920x1200 may simply not fit in 860x480
 - Also, what is the input mechanism?

Changing situations

- May lose network coverage
 - Applications must degrade gracefully

You always *do* check for error values from API calls, right?

- May start to run out of power
 - Must absolutely minimize what apps do
 - Must survive power outages gracefully

Database transactions and journaling file systems are your friends.

- Incoming phone call
 - Applications must yield immediately to allow the high priority task to run

User interaction

- Device rotation
 - Mobile devices often have accelerometers – can tell whether it is in landscape or portrait mode
 - Applications should register for orientation change notifications and re-layout accordingly
- Input methods
 - Hardware keyboard, virtual keyboard, finger input, Bluetooth keyboards and mice, ...
 - Extra controls such as microphone buttons

Catching rotation on Maemo

MyReceiverClass inherits *QObject*, and implements slot *orientationChanged()*.

```
MyReceiverClass * receiver = new MyReceiverClass(this);
QDBusConnection systemBus = QDBusConnection::systemBus();
systemBus.connect("com.nokia.mce",
                 "/com/nokia/mce/signal",
                 "com.nokia.mce.signal",
                 "sig_device_orientation_ind",
                 receiver, SLOT(orientationChanged(QString)));
```

DBus is a message passing system.

MCE is the Mode Control Entity (a system process) in Maemo.

When MCE sends the *sig_device_orientation_ind* via the system message bus, your object's slot *orientationChanged()* will get called with argument "portrait" or "landscape".

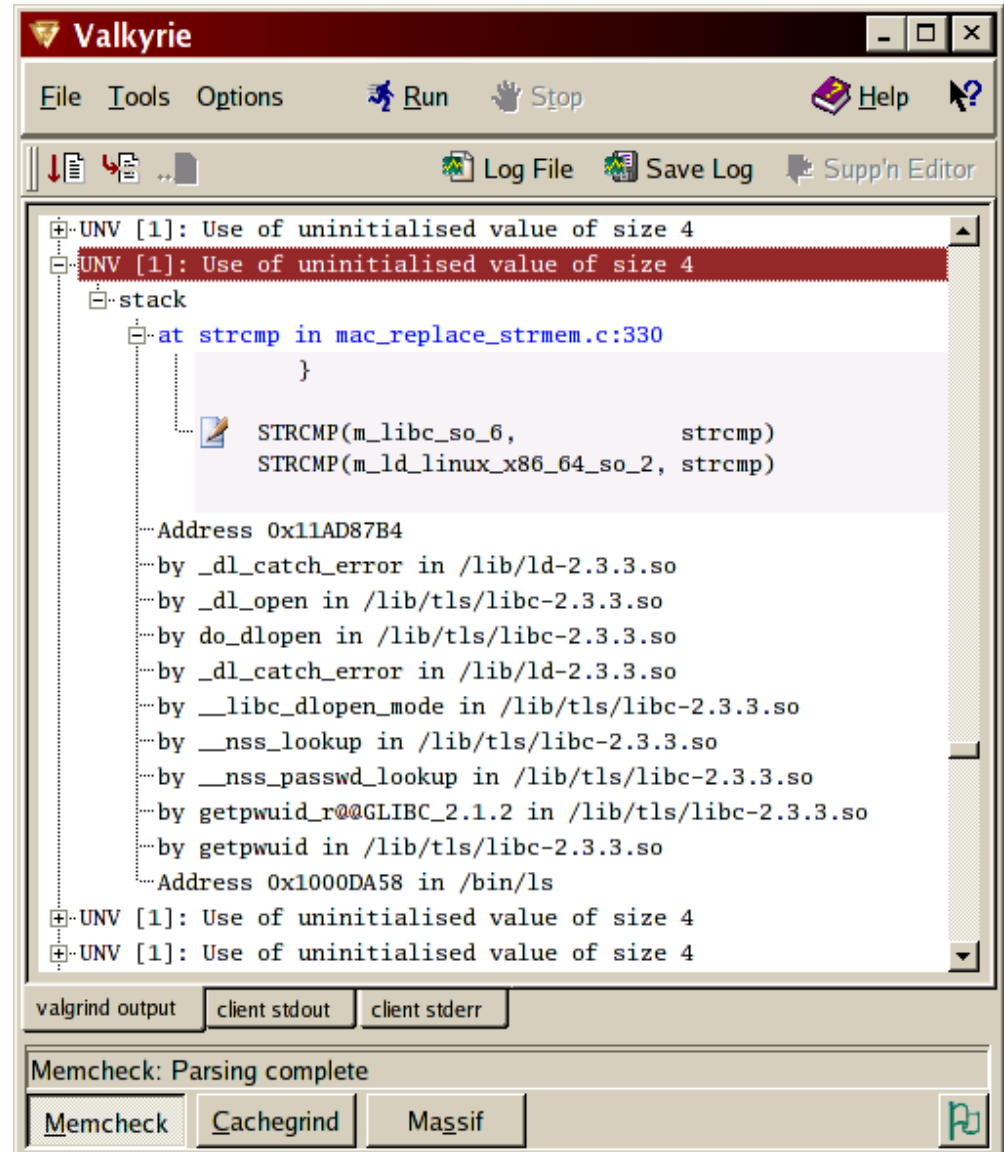
Memory management

- Memory leaks cause device to reboot
 - User will not like this! (user = *you*)
 - Careful weeding out of dynamic memory allocation problems is needed
 - Use QObjects, tools such as valgrind
- Limited amount of memory in device
 - Swapping is slow and expensive power-wise
 - Use as little memory as you can, free memory when not needed

Arguably, Java is better than C/C++ in this regard as it handles memory deallocation automatically.

Tool: valgrind

- Supports x86, older ARM chips
- Full ARMv7 support coming soon
- Multiple GUI front-ends



Multitasking

- Running multiple applications simultaneously requires special care
 - You run out of memory, and device reboots
 - Background apps eat all your CPU, and you can't answer phone calls
- iPhone OS just tells your app it's about to be killed
 - Your app must save state information to disk, so that it can resume smoothly when restarted

This is clever, because only one app at a time is in memory.



Multitasking

- Android does automatic suspend/resume
 - Stores idle app state on disk automatically
 - Reloads app state when app is resumed, which causes occasional stalls
- Maemo/MeeGo does regular Linux multitasking
 - cgroups to prioritize process groups in memory
 - Uses swap to extend physical memory, which causes occasional stalls

Android 2.2 has a task manager, where you can kill idle apps by hand.

User interface design

- Mobile design patterns
 - Mobilize, Don't Miniaturize
 - The Carry Principle
 - Context Sensitivity
- New research coming out all the time
 - Including 3D interfaces in 1-2 years
 - Tricky to combine 3D and touch...

Multiplatform applications

- Qt is supported “everywhere”
 - Encourages creation of multiplatform applications
 - But: even if the core application works everywhere, the user interface may not
 - #ifdef statements in code to instantiate different UI code for different UX environments?
 - QtMobility APIs to query system features

Web widgets

- WebKit is the standard web runtime (WRT)
 - Provided by Android, Symbian, Maemo/MeeGo
 - Differences in JIT support
 - Platform service interfaces visible in JavaScript
- Applications as widgets run in a WRT process context
 - Similar considerations as for native applications
 - Often possible to embed to native applications, sometimes just use in homescreen etc.

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