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Deterministic Software

In last month's Hot Topic we discussed the concept of a wireless network as a real time operating system – a network that responds to external asynchronous traffic in a predictable amount of time. The preconditions for this included a flexible layer one and an ATM based Layer 2.

The job of the flexible Layer One and dynamic rate matched Layer Two is to preserve the properties of the traffic flowing down from the higher layers of the protocol stack and to protect traffic and higher layer application software from the effects of a variable quality radio channel. The end objective is to achieve application consistency and application stability. Note also the need to support simultaneous multiple channels per user in the uplink and downlink implying a need for virtual paths and virtual channels across the radio layer and into and through the network. In practice, this is only reliably achievable by implementing an ATM radio layer with 10 millisecond dynamic rate matching linked to ATM in the access network – a hardware centric network model.

Failure to manage the asynchronous traffic flowing into and out of a wireless network can result in protocol and application instability. Protocol and application stability is therefore dependent on Layer One flexibility and the rate matching capability at Layer Two.

However, determinism – the delivery of traffic and applications within predictable and stable performance bounds – requires a measure of real time discipline at **all** layers of the protocol stack. RSVP, Diffserv, MPLS, SIP, SMIL and RTP are not intrinsically deterministic, particularly when used together. Similarly the application layer (Layer 7) is not intrinsically deterministic. In general it can be said that as functionality and flexibility increase at the application layer, determinism becomes harder to achieve.

Figure 1 illustrates how this happens.

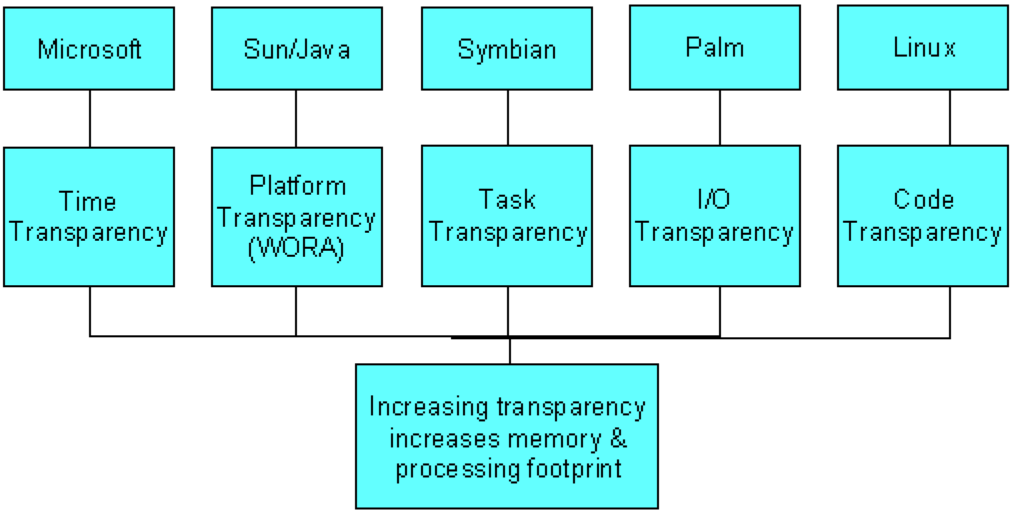

Figure 1: Application Layer Operating Systems

Let us take as an example five operating systems – Microsoft, Sun/Java, Symbian, Palm and Linux.

Each of these systems has a legacy differentiation in terms of the user experience. Microsoft has traditionally delivered time transparency ie a measure of backwards compatibility. Sun/Java offers write once run anywhere platform transparency, Symbian traditionally majors on multi-tasking, a legacy of Psion's software philosophy, Palm offer a wide range of input and output (I/O) options and Linux offers code transparency.

Increasing any of these transparency factors increases code and processing footprint implying additional processor delay and delay variability ie transparency implicitly compromises the determinism of the operating system. Similarly, the more flexibility provided, the harder it is to deliver real time performance.

One answer is to reduce the amount of flexibility and address real time processing delay and delay variability by using hardware. Savaje, a company that originally evolved from Lucent's Inferno project, is an example of a J2ME Java based o/s which uses MediaQ's graphics accelerator to overcome the delay and delay variability introduced by M-PEG4 encoding/decoding.

Similarly, Montavista, a company presently promoting LINUX as an application layer RTOS make a persuasive case for delivering stable and predictable application layer performance.

The problem with predictability is that it comes at a price and part of the price is power efficiency. It is a perfectly laudable aim to reduce microprocessor power drain by implementing power down (sleep and slumber modes) but intuitively, sleep and slumber modes increase task and interrupt latency. It is a perfectly laudable to reduce microprocessor power drain by implementing voltage and frequency scaling but scaling increases task and interrupt latency (admittedly only a few tens of microseconds but still enough to compromise real time performance).

The diversity of deterministic hardware and software also makes it harder to deliver determinism in practice. An RTOS in the microcontroller (or microcontrollers as there will be at least two in a multimedia phone) has to work with the RTOS in the DSP and the RTOS in the memory and power management modules. Rather like traffic shaping protocols, real time operating systems when used in isolation may deliver real time performance, it's when they are used together that problems arise. Consider also that ambiguity at the application layer can be amplified as the application moves down the protocol stack and may cause application and protocol instability.

It is not so bad if there is a stable point at which instability occurs but in practice it will be likely that the point of instability, particularly in a wireless IP network will be hard to predict – unpredictably unpredictable.

The pragmatic answer is to make the application layer less flexible, ie give the user less choice (probably not a bad idea given the over-complexity of most graphical user interfaces),

A less flexible application layer makes it easier to deliver real time performance from the application layer which can then be passed down to lower layers in the protocol stack which if they are doing their job properly will preserve the real time properties of the application as it moves into and across the network.

This measure of control will be particularly important for applications which we define as conversational variable rate supporting full duplex simultaneous voice and video, ie applications that cannot tolerate buffering being intrinsically sensitive to delay and delay variability (application and network jitter).

References:

Montavista – www.mvista.com
SAVAJE – www.savaje.com

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