Virtualization, Empathic Systems, and Sensors
Recent Work in the Prescience Lab

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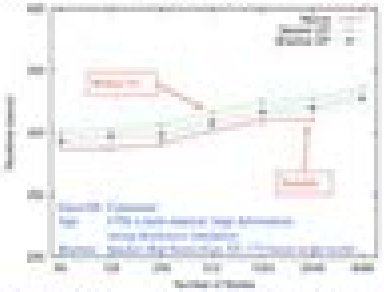
Virtualization (v3vee.org)

Palacios

A new, publicly available, open source virtual machine monitor for modern x86 architectures that runs on Cray XT supercomputers, clusters (Infiniband and Ethernet), servers, desktops, etc.

Palacios is intended to support research in high performance computing and computer architecture, in addition to systems. It can be easily embedded into other OSes.

Palacios, when embedded in a lightweight kernel, such as Sandia National Lab's Kitten, forms a compact, type I pure VMM suitable for virtualizing a supercomputer at scale with minimal overhead even when running tightly coupled, communication-intensive parallel applications on HPC OSes.



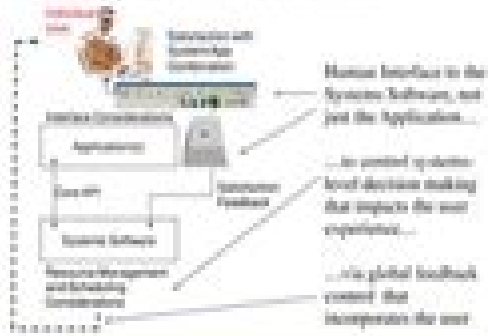
Older Work: Virtuoso: Adaptive Virtual Computing

- Provides: tell computational and communication bandwidth
- Users run collections of virtual machines (VMs) that are interconnected by overlay networks
- Replacement for buying machines
- That continuously adapts... to increase the performance of your existing, unmodified applications and operating systems

Empathic Systems (empathicsystems.org)

Experimental Computer Systems Researchers Should...

- Incorporate user studies into the evaluation of systems
  - No such thing as the typical user
  - Variation in user satisfaction with given operating point is huge
- Incorporate direct user feedback into the design of systems
  - No such thing as the typical user
  - Measure and leverage that high user variation



We Have Applied This Idea Extensively and Successfully

- **User-driven scheduling of interactive virtual machines** allows user-active users to trade off between cost and interactive performance via a simple tactile interface
- **User-driven dynamic voltage and frequency scaling** exploits user feedback to lower power consumption on a laptop computer by considerable amounts while maintaining high user satisfaction
  - 12-50% lower power during human-active intervals: 22% better than Windows DVFS
  - PEWMA: to balance rate of system control changes: 12.5% better
  - DVFS (control set range from hardware measures to get user satisfaction): 25% better
  - PVF (frequency-based satisfaction): 12% better
- **Speculative remote display** predicts and shows server-system content on the client, ameliorating network latency effects. Users can trade off between display correctness and responsiveness
- **Empathic network link scheduling** provides user satisfaction-driven control over scheduling the broadband router link in home networks. It increases overall user satisfaction by 34% over an 81.9% link, and by 195% compared to a static 802.11g link.
- **User-presence-driven display power management** controls laptop LCD backlight based on presence determined by ultrasonic sonar on commodity hardware

We Are Now Studying Techniques for Free, Biometric-based, Continuous Measurement of User Satisfaction

Left to right: Keystroke force sensors, galvanic skin response, pupil dilation, active discomfort, sonar, face detection, gaze tracker, and dynamics comparison, infrared camera, accelerometer

Sensors (absynth-project.org)

Wireless sensor network applications are extremely challenging for domain scientists to implement.

Success typically requires either collaboration with a "CS side" sensor networking researcher or with an expensive embedded systems engineer.

However, many prospective applications are either conceptually simple or fit into one of a small number of classes.

We design, implement, and evaluate (through carefully controlled user studies) programming languages and systems specifically for domain scientists and other non-experts.

Archetype-based Design

- Study of the literature for deployed applications suggests almost all fit into seven classes
- Proposal: develop an "archetype language" for each class combined with an generic template (an "archetype") in that language. The user answers questions about their potential application to lead to an archetype. We assemble the archetype for his specific purposes. The system synthesizes a hardware/software design.
- Archetype languages are designed for domain scientists. They are also extremely high-level, allowing expression of the archetype in a page of code, and freeing the hands of the synthesis and compilation mechanisms.

Proposed languages for three identified archetype fast high success rate and low development time in user study comparing it to other languages

Language	Success rate			Develop time (min)		
	P1	P2	P3	P1	P2	P3
SensQer	1.1	1.1	N.A.	1.7	1.1	N.A.
MASP	2.2	2.4	2.4	30	30	29.1
TinySQL	3.4	2.1	3.1	17.1	27.1	N.A.
Reg Simulator	3.4	3.3	3.3	34	N.A.	N.A.
TinyScript	3.1	3.1	3.4	N.A.	N.A.	N.A.
MASP2	3.3	3.4	3.3	3	4.7	23.1

A BASIC Approach

- The BASIC programming language proved to be a great success in getting naive users (children) to write simple programs on resource-constrained embedded systems (the millions of home computers of the early '80s).
- We have developed an BASIC for use in sensor networks. The language is extended with sensor network concepts needed for writing node-oriented programs, and these concepts are presented via user-study tested constructs (found to be sensible to non-programmers).
- Depending on the task, 65-95% of subjects with no prior programming experience can write simple, power-efficient, node-oriented sensor network programs after a 50 minute tutorial. 67-100% of those matched to typical domain scientist expertise can do so.

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Hussin A.Rothana

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