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

Virtualization (v3vee.org)

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Palacios
An OS Independent Embeddable VMM

A new, publicly available, BSD-licensed, 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. Current embeddings include Linux, Kitten, and Minix 3.

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.

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 HaveApplied This Idea Extensively and Successfully

- User-driven scheduling of interactive virtual machines allows even naïve 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.
- UDVS (user presses button when irritated): 22% better than Windows DVFS
- PICS (evaluates rate of screen content change): 12.1% better
- DVVS (neural net maps from hardware measures to per-user satisfaction): 25% better
- PTP (biometrics-based satisfaction): 12% better
- Speculative remote display predicts and draws server screen content on the client, ameliorating network latency effects. Naïve users can trade off between display correctness and responsiveness.
- Empathic network linking scheduling provides user satisfaction-driven control over scheduling the broad band router link in home networks. It increases overall user satisfaction by 24% over an FCFS link, and by 19% compared to a static WFQ link.
- User-driven display power management controls laptop LCD backlight based on presence determined by ultrasonic on commodity hardware

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

- Determine room based on acoustic signature
- No infrastructure required
- New rank-order filtered repeated spectral analysis technique can be implemented on mobile phones
- Technique can be combined with WiFi localization to enhance accuracy

Human Interface to the Systems Software, not just the Application…

- Control systems-level decision making that impacts the user experience…
- Via global feedback control that incorporates the user

Room-level Localization using Acoustic Background Spectra

- Ranking from highest to lowest confidence

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 a generic template (an “archetype”) in that language. The user answers questions about their potential application to lead to an archetype. He modifies 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 tools.

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

A BASIC Approach

- The basic programming language proved to be a great success in getting naïve users (children) to write simple programs on resource-constrained embedded systems (the millions of home computers of the early ’80s).

- We have developed an ARCH 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, 45-55% of subjects with no prior programming experience can write simple, power-efficient, node-oriented sensor network programs after a 30 minute tutorial. 67-100% of those matched to typical domain scientist expertise can do so.

Collaborators on the efforts noted here are Jack Lange (U. Pittsburgh), Patrick Bridges (U. New Mexico), Kevin Pedretti (Sandia National Labs), Gokhan Memik (Northwestern), Robert Sick (U. Michigan), and our amazing students.

Peter Dinda is a professor in the Department of Electrical Engineering and Computer Science at Northwestern University, and head of its Computer Engineering and Systems division, which includes 17 faculty members. He holds a B.S. in electrical and computer engineering from the University of Wisconsin and a Ph.D. in Computer Science from Carnegie Mellon University. He works in experimental computer systems, particularly parallel and distributed systems. His research currently involves virtualization for distributed and parallel computing, programming languages for parallel computing, programming languages for sensor networks, and empathic systems for bridging individual user satisfaction and systems-level decision-making.