Ptolemy Miniconferences

Edward A. Lee

Robert S. Pepper Distinguished Professor

Ninth Biennial Ptolemy Miniconference

February 16, 2011
Berkeley, CA, USA

Ptolemy Project

February, 2011

Staff:
- Christopher Brooks
- Edward A. Lee (PI)
- Stavros Tripakis
- Mary P. Stewart

Postdocs:
- Patricia Derler
- Slobodan Matic
- Eleftherios Matsikoudis
- Jan Reineke

Grad Students:
- Ilge Akkaya
- Dai Bui
- Shanna-Shaye Forbes
- Ben Lickly
- Isaac Liu
- Chris Shaver
- Jia Zou
- Mike Zimmer

Visiting Scholars:
- Hugo Andrade
- Janette Cardoso
- John Eidson

Photo by Chamberlain Fong

The 1st Biennial Ptolemy Miniconference: 1995

The Ptolemy Project

Shuvra Bhattacharyya
Joseph T. Buck
Wan-Teh Chang
Brian L. Evans
Steve X. Gu
Sangjin Hong
Christopher Hylands
Asawaree Kalavade
Alan Kamas
Allen Lao
Bilung Lee
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David G. Messerschmitt
Praveen K. Murthy
Thomas M. Parks
José Luis Pino
Farhana Shiekh
S. Sriram
Juergen Teich
Warren W. Tsai
Patrick J. Warner
Michael C. Williamson

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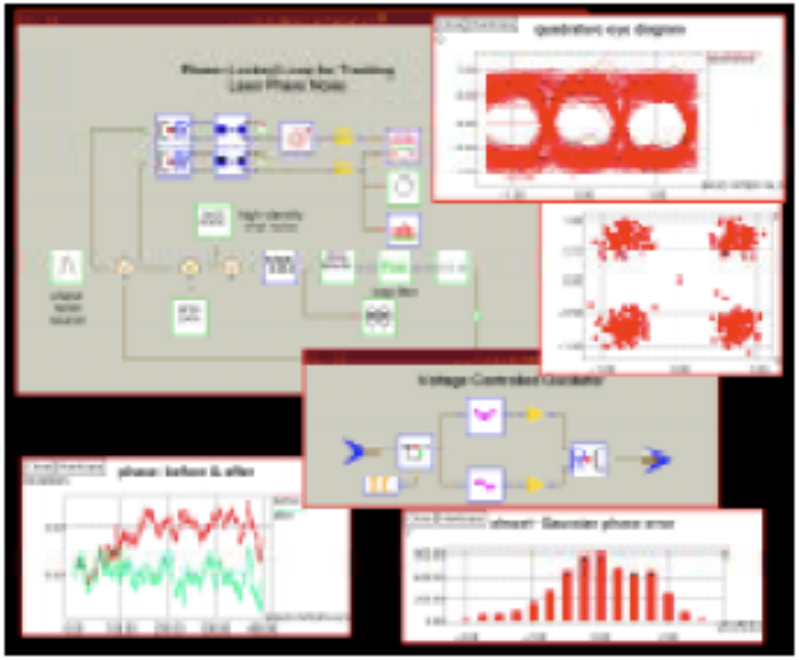
System-Level Design of Signal Processing Systems

Ptolemy Research

- Design complexity management.
- Visual, algorithm-level system design.
- Formal methods for dataflow systems.
- Programming language semantics.
- Software and hardware synthesis.
- Parallel architectures, partitioning, and scheduling.



This highly multidisciplinary project addresses system-level design and implementation of signal processing systems.

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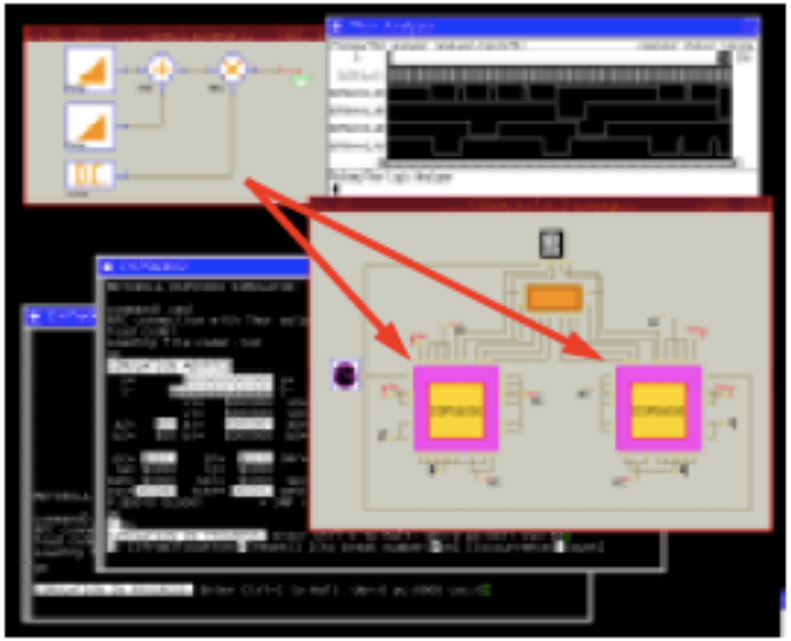
Implementation of Signal Processing Systems

Hardware/ Software Synthesis

- Design of heterogeneous embedded systems.
- Real-time systems.
- Synthesis of software from dataflow graphs.
- System-level hardware design.
- Cosimulation of hardware and software.
- Codesign of hardware and software.



The design philosophy in Ptolemy is heterogeneous, allowing for effective use of specialized design tools within a general system-level design environment.

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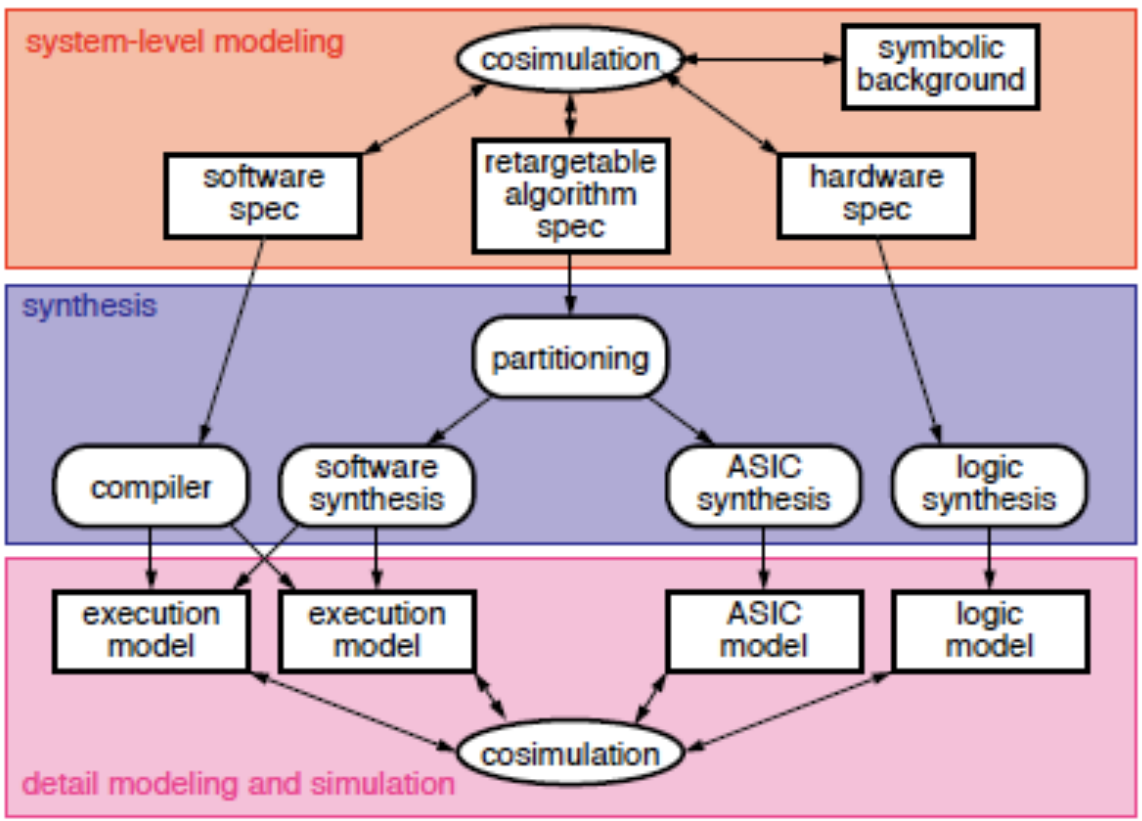
Heterogeneity in System-Level Design



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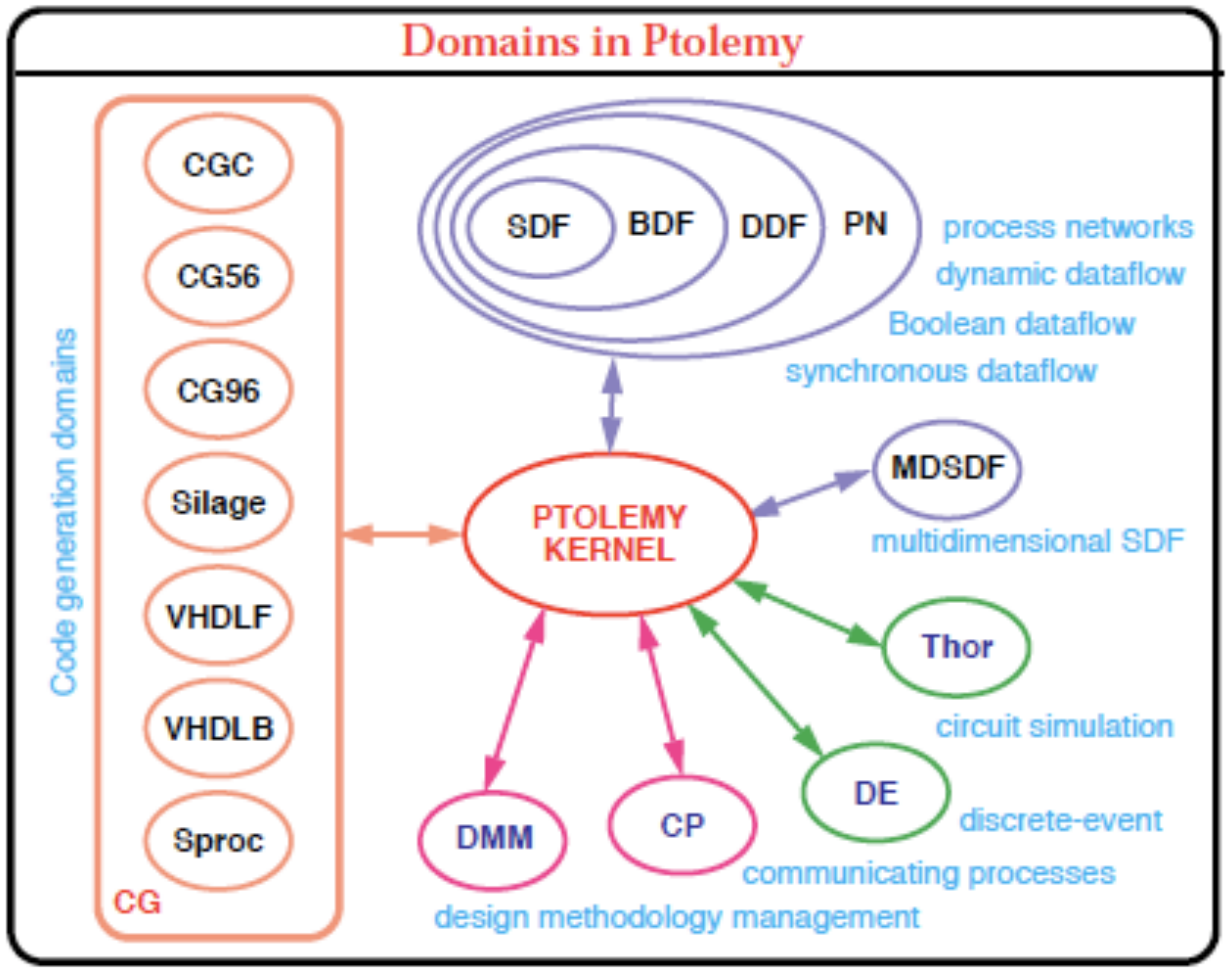
Domains in Ptolemy



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Where to From Here?

- Real-time scalable computing.
- Scalable embedded systems design.
- Design migration from abstract to concrete.
- Formal methods based on partial orders.
- Hybrid systems: combining FSM with dataflow.
- Modeling and analysis of random systems.
- Design of nondeterminate systems.
- Complexity management.
- Design visualization and documentation.
- Partial evaluation and incremental compilation.
- Models for back-end signal interpretation.
- Heterogeneous scheduling.

UNIVERSITY OF CALIFORNIA AT BERKELEY

The 2nd Biennial Ptolemy Miniconference: 1997

Organizational

Staff

Diane Chang, administrative assistant
Kevin Chang, programmer
Christopher Hylands, programmer analyst
Edward A. Lee, professor and PI
Mary Stewart, programmer analyst

Postdocs

Praveen Murthy
Seehyun Kim
Raja Nagarajan
John Reekie
Dick Stevens (on leave from NRL)

Students

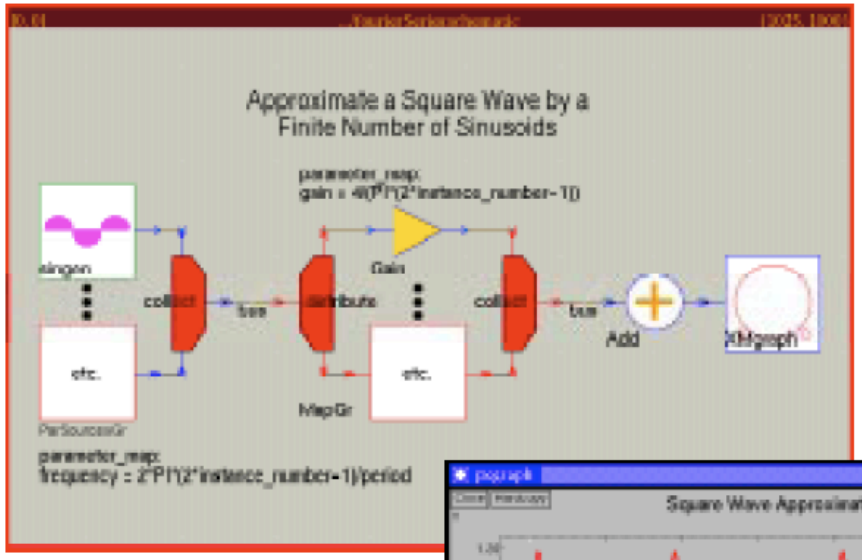
Sunil Bhave
Cliff Cordeiro
John Davis
Stephen Edwards
Ron Galicia
Mudit Goel
Michael Goodwin
Luis Gutierrez
Bilung Lee

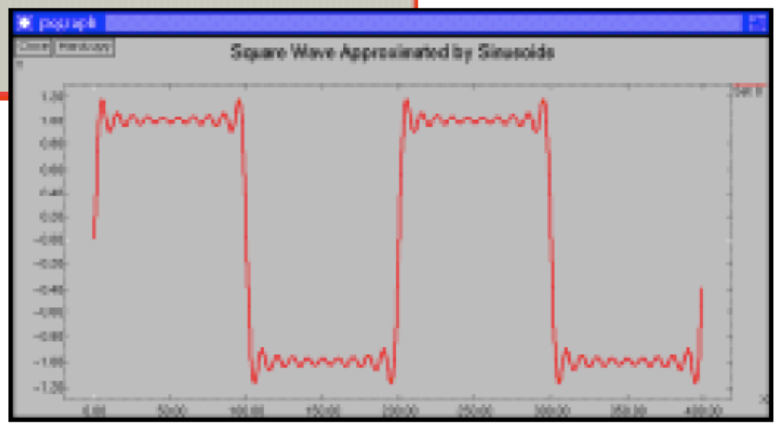
Michael C. Williamson
Yuhong Xiong

Key Outside Collaborators

Shuvra Bhattacharyya (Hitachi)
Joseph T. Buck (Synopsys)
Brian L. Evans (UT Austin)
Soonhoi Ha (Seoul N. Univ.)
Tom Lane (SSS)
Thomas M. Parks (Lincoln Labs)
José Luis Pino (Hewlett Packard)

Visual Design





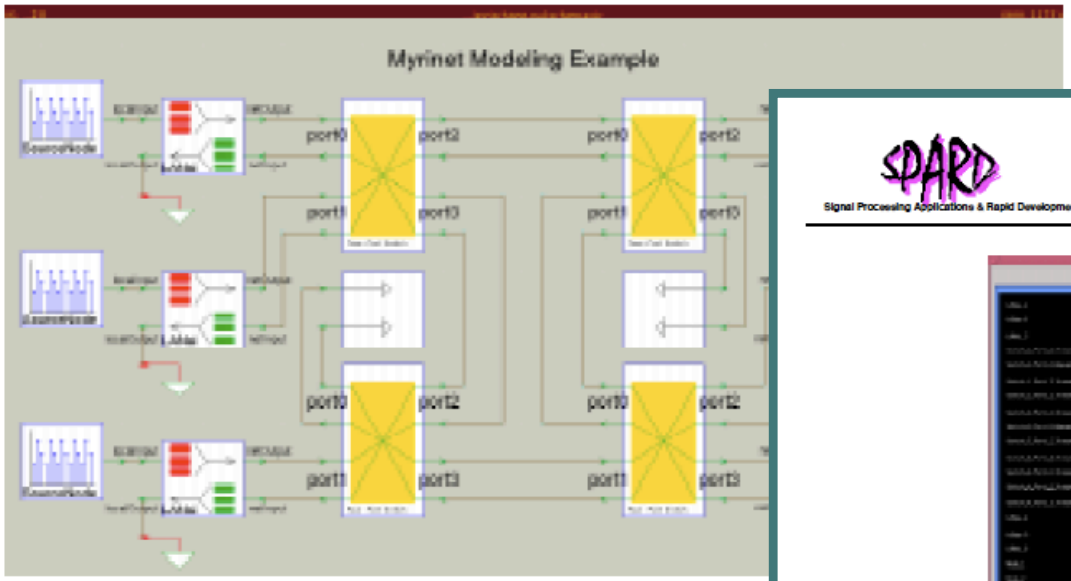
- **Formal properties.**
- **Scalability.**
- **Scheduling.**
- **Partitioning.**

The 2nd Biennial Ptolemy Miniconference: 1997

Simple Myrinet Modeling Example

SPARD
Signal Processing Applications & Rapid Development

SANDERS
A Lockheed Martin Company



Simple Myrinet Modeling Example

Modeling Results for Simple Example

SPARD
Signal Processing Applications & Rapid Development

SANDERS
A Lockheed Martin Company

Gantt Tool Display of Simple Myrinet Modeling Example

- **Yellow: start-up latency**
- **Blue: normal transmission/reception**
- **Green: processing of data on Node**
- **Orange: origin of contention, one or more packets queued in the switch**
- **Red: propogating effect of switch contention down current data path**

High-Performance Scalable Computing (HPSC) modeling by Sanders, a Lockheed-Martin Company.

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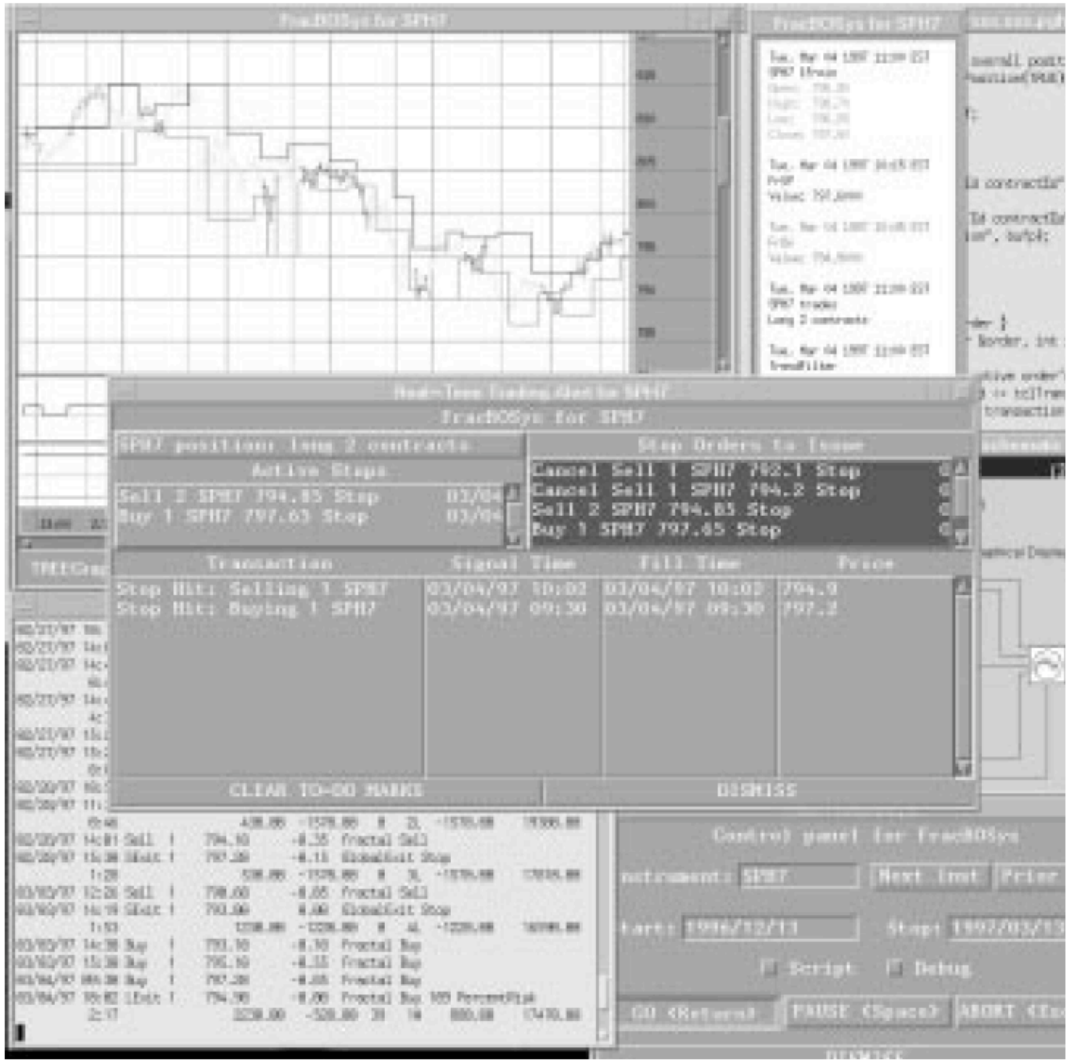
Live trading example

Applications of Ptolemy in Securities Trading

or,
Playing the Markets with Ptolemy

Tom Lane

Structured Software Systems, Inc.



The 2nd Biennial Ptolemy Miniconference: 1997

Modeling Free Space Optoelectronic Systems Using Ptolemy

Steven P. Levitan
Donald M. Chiarulli
Tim P. Kurzweg
Mark A. Rempel

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University of California, San Diego

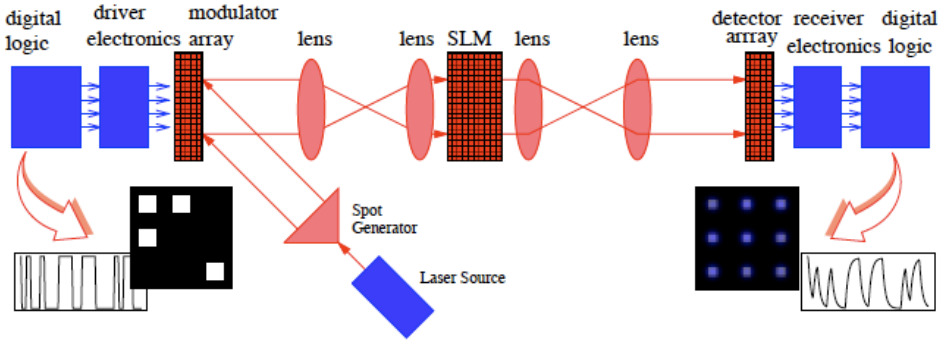
Funding: National Science Foundation- MIP-9421777

Overview

Chatoyant is a computer aided design tool for the design of *Free Space Optoelectronic Information processing (FSOI) Systems.*

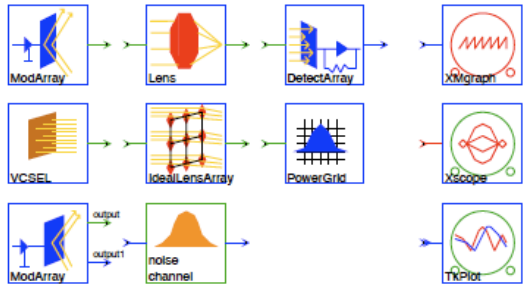
- Simulation - Analysis - Synthesis - Interface

Enable the modeling of FSOI systems without costly prototyping



chatoyant

Chatoyant Stars in Ptolemy



lodulators	Detectors	Lenses	Lenslets
rea	Detector Size	Focal Length	Focal Length
pacing	Detector Spacing	Diameter	Diameter
ambda	Distance	Distance	Distance
potsize	x, y offsets	x, y offsets	x, y offsets
Filename	Radius of Integration		Spacing
Gauss/Ray	R, C, A		Number

chatoyant

The 2nd Biennial Ptolemy Miniconference: 1997

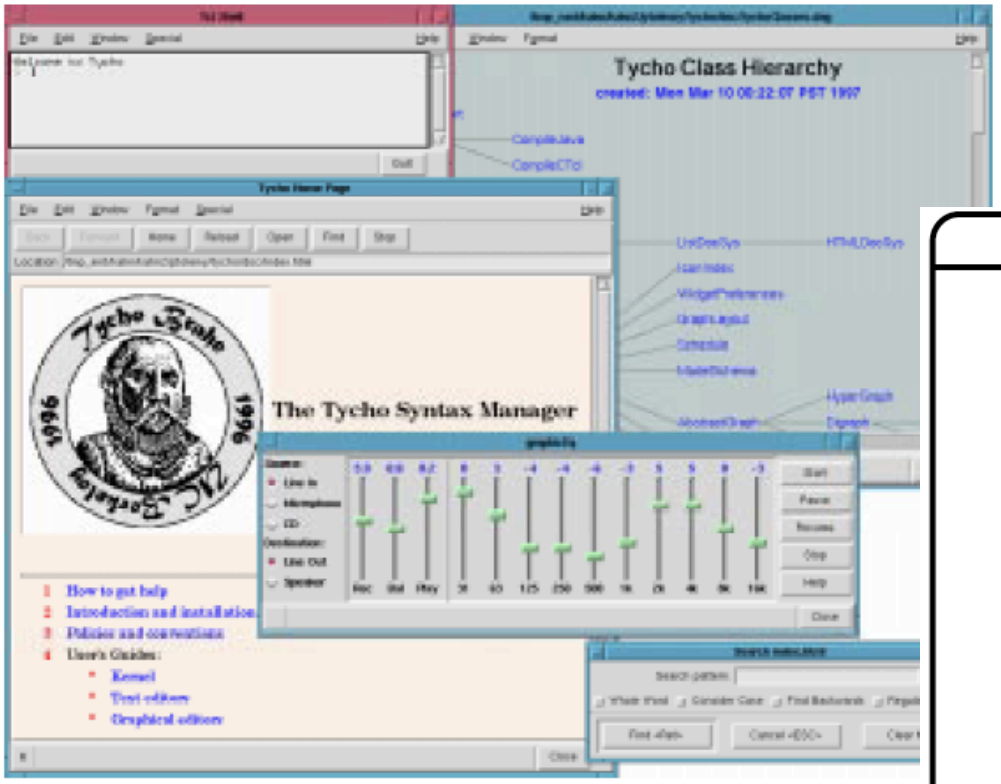
Tycho

Christopher Hylands
Edward A. Lee
H. John Reekie

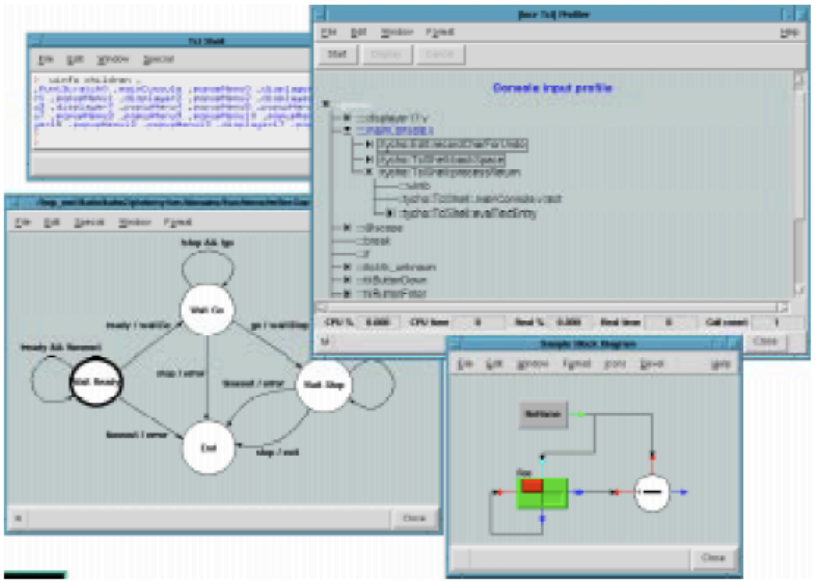
Contributors:

Kevin Chang
Wan-Teh Chang
Cliff Cordeiro
Wei-Jen Huang
Joel King
Farhana Sheikh
Mario Jorge Silva

Tycho (1)



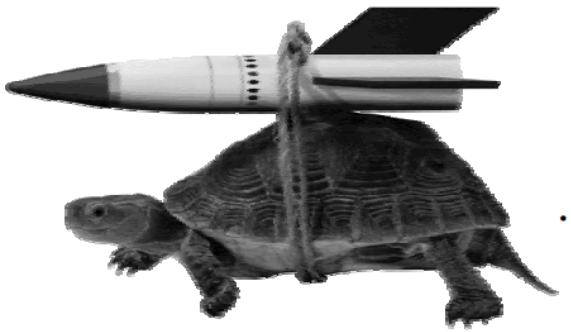
Tycho (2)



3rd Biennial PtConf 1999

The switch to Ptolemy II

Modeling in Java ?!?!?!?!?



- Choosing the best modeling technique can have a far bigger impact than using a faster modeling tool.
- Mixing modeling techniques permits multi-domain modeling using the best available modeling techniques.

- Threads, objects, and UI infrastructure helps with both.
- Network integration of Java promotes sharing of modeling methods.
- Java performance and infrastructure is rapidly improving.

Ptolemy Classic vs Ptolemy II

C++	Java
Mature platform	Experimental
Does code generation	All Java (now)
Monolithic tool	Modular packages
Standalone	Networked
Sequential	Multi-threaded
GUI-centric	Applet-centric
Ad-hoc development	Good software practice
Dynamically linked	Reflective
Astronomical lexicon	Boring lexicon

The Ptolemy Project

Heterogeneous Modeling and Design

Principal Investigator
Edward A. Lee

Staff
Jennifer Basler
Christopher Hylands
Mary P. Stewart

Postdocs/Researchers
Bart Kienhuis
James Lundblad
John Reekie

Students
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Ron Galicia
Mudit Goel
Bilung Lee
Michael Leung
Jie Liu
Xiaojun Liu
Lukito Muliadi
Steve Neuendorffer
Neil Smyth
Jeff Tsay
William Wu
Yuhong Xiong

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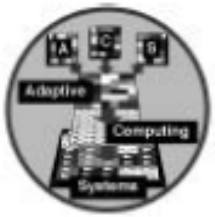
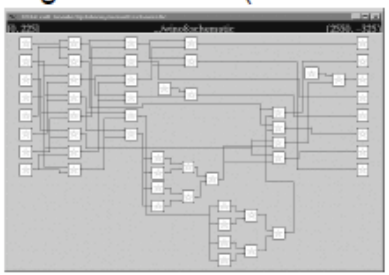


Algorithm Analysis and Mapping Environment for Adaptive Computing Systems

Eric Pauer, Cory Myers, Ken Smith, and Paul Fiore
[illegible]er,cory,jmsmith,pfiore}@sanders.com
Lockheed Martin Company
Nashua, NH 03061

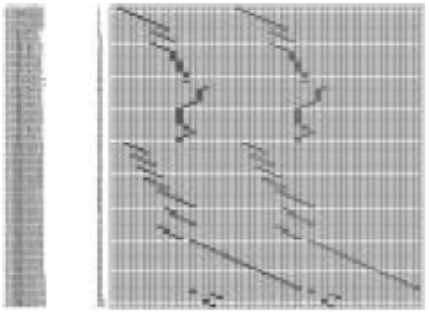
ACS Domain - CGFPGA Target

Winograd dataflow (ACS domain)



CGFPGA target yields: VHDL design and schedule

VHDL design (generated)

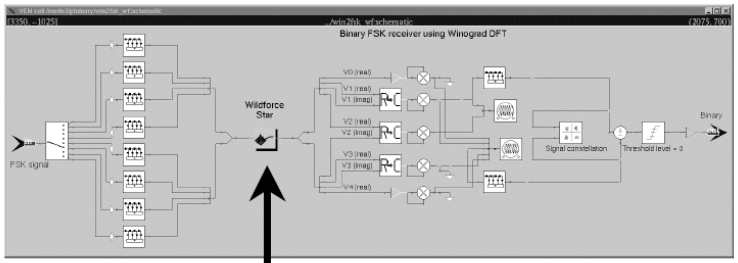


Dataflow/Hardware schedule

The results are sent to synthesis and place/route, yielding complete FPGA implementation!

Hardware-in-the-loop

SDF Galaxy



SDF Wildforce star executes complete FPGA design in hardware on Annapolis Wildforce FPGA board

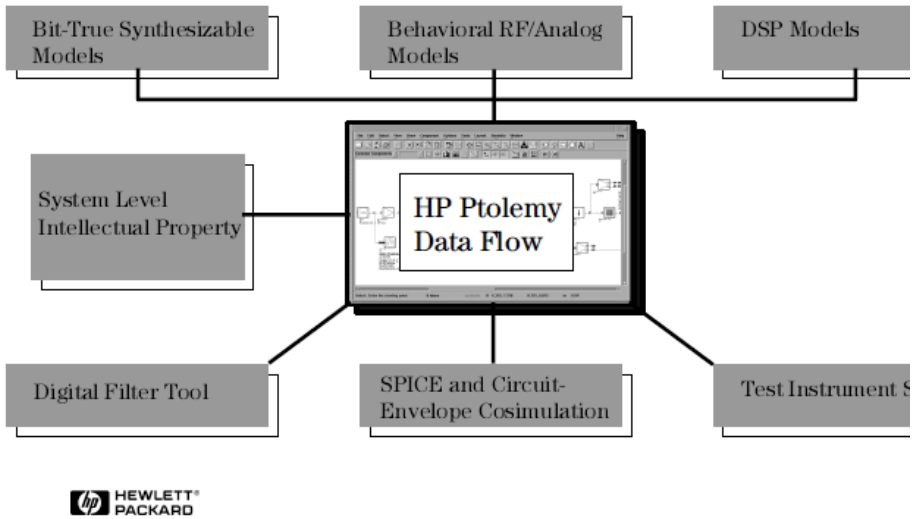
3rd Biennial PtConf 1999

Cosimulating Synchronous DSP Designs with Analog RF Circuits

José Luis Pino and Khalil Kalbasi

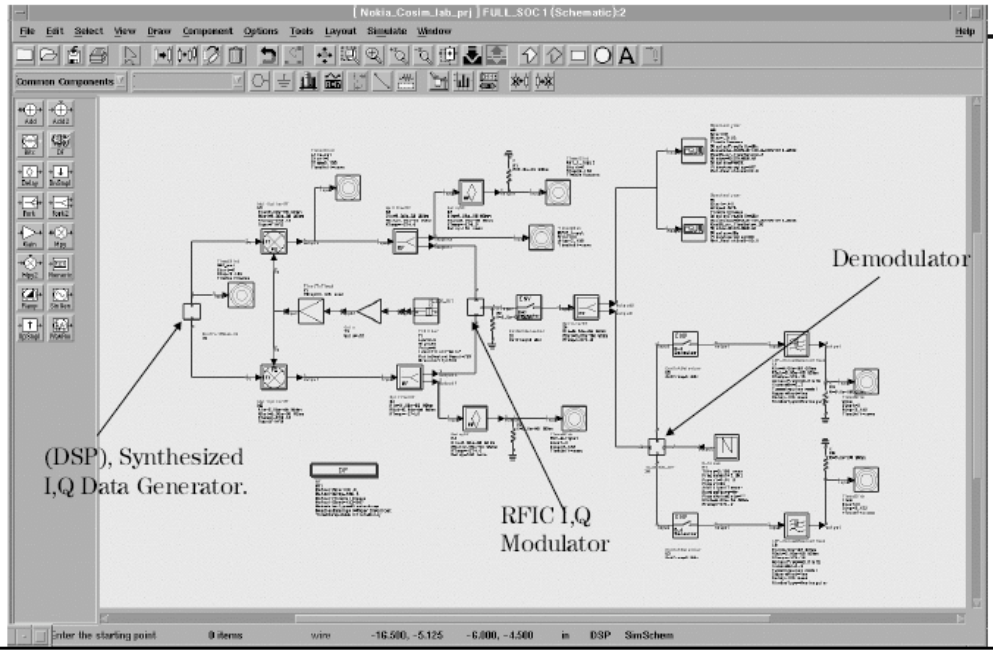
HEWLETT PACKARD

HP Ptolemy



HEWLETT PACKARD

Example: 16 QAM Tx/Rx



4th

2001

4th 2001

ESPADON EUROFINDER

Rapid Prototyping of RADAR Signal Processing Systems using Ptolemy Classic

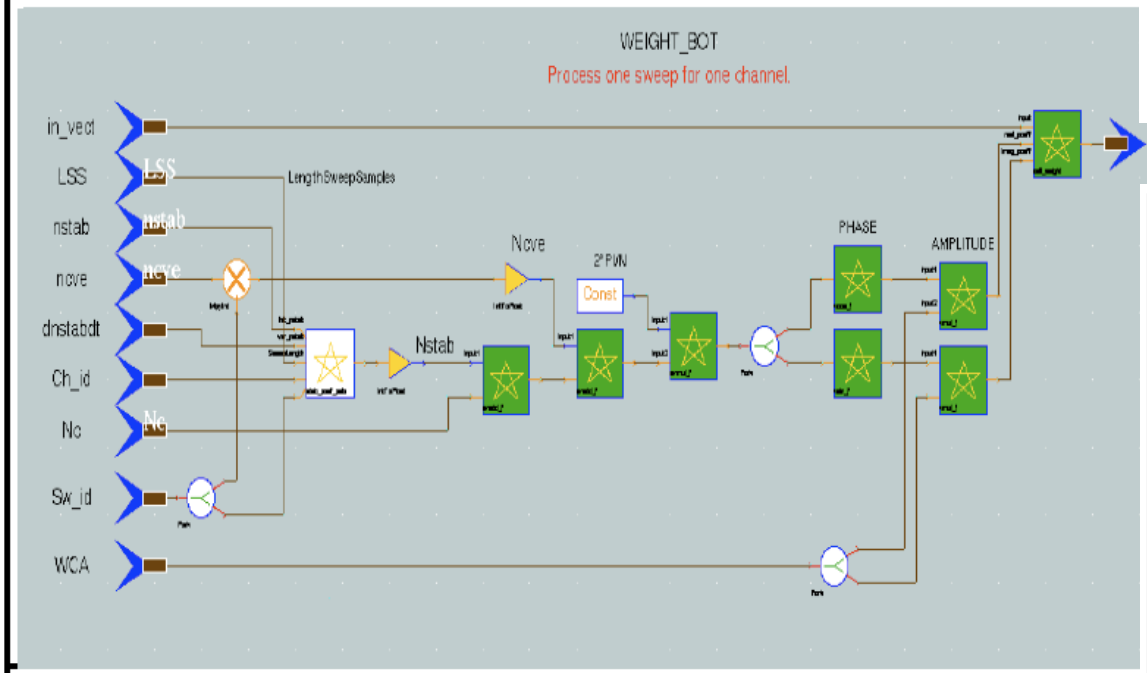
Ptolemy MiniConference UCB

Denis Aulagnier, Patrick Meyer, Hans Schurer, Xavier Warzee,
THALES

THALES Matra BAe Dynamics BAE SYSTEMS THOMSON MARCONI SONAR

ESPADON EUROFINDER

BENCHMARK FINAL DESIGN (2)



THALES Matra BAe Dynamics BAE SYSTEMS THOMSON MARCONI SONAR

ESPADON EUROFINDER

CONCLUSIONS (1)

- Main functional requirements are met by the final design (12 of the 19 requirements)
- Throughput and latency requirements are almost met; expected to be met in case of full speed G4 daughter cards and/or VSIPL functions redesign
- Review of graphical Ptolemy designs seems faster and more efficient than code reviews
  - Disadvantage is parameter handling and scope.
  - Design is highly multi-rate, but this is difficult to see
  - Some functionality is inside stars (hidden)
- Total design, validate & test time for bare beamformer was 354.5 hours, while normal development takes 481 hours: Approximately 36% faster (improvement ~1.36)

THALES Matra BAe Dynamics BAE SYSTEMS THOMSON MARCONI SONAR

5th 2003

CHE

Director:

- Edward A. Lee

Staff:

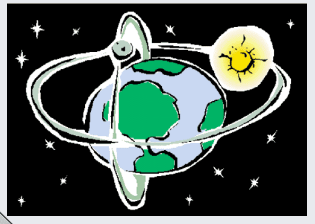
- Christopher Hylands
- Susan Gardner (Chess)
- Nuala Mansard
- Mary P. Stewart
- Neil E. Turner (Chess)
- Lea Turpin (Chess)

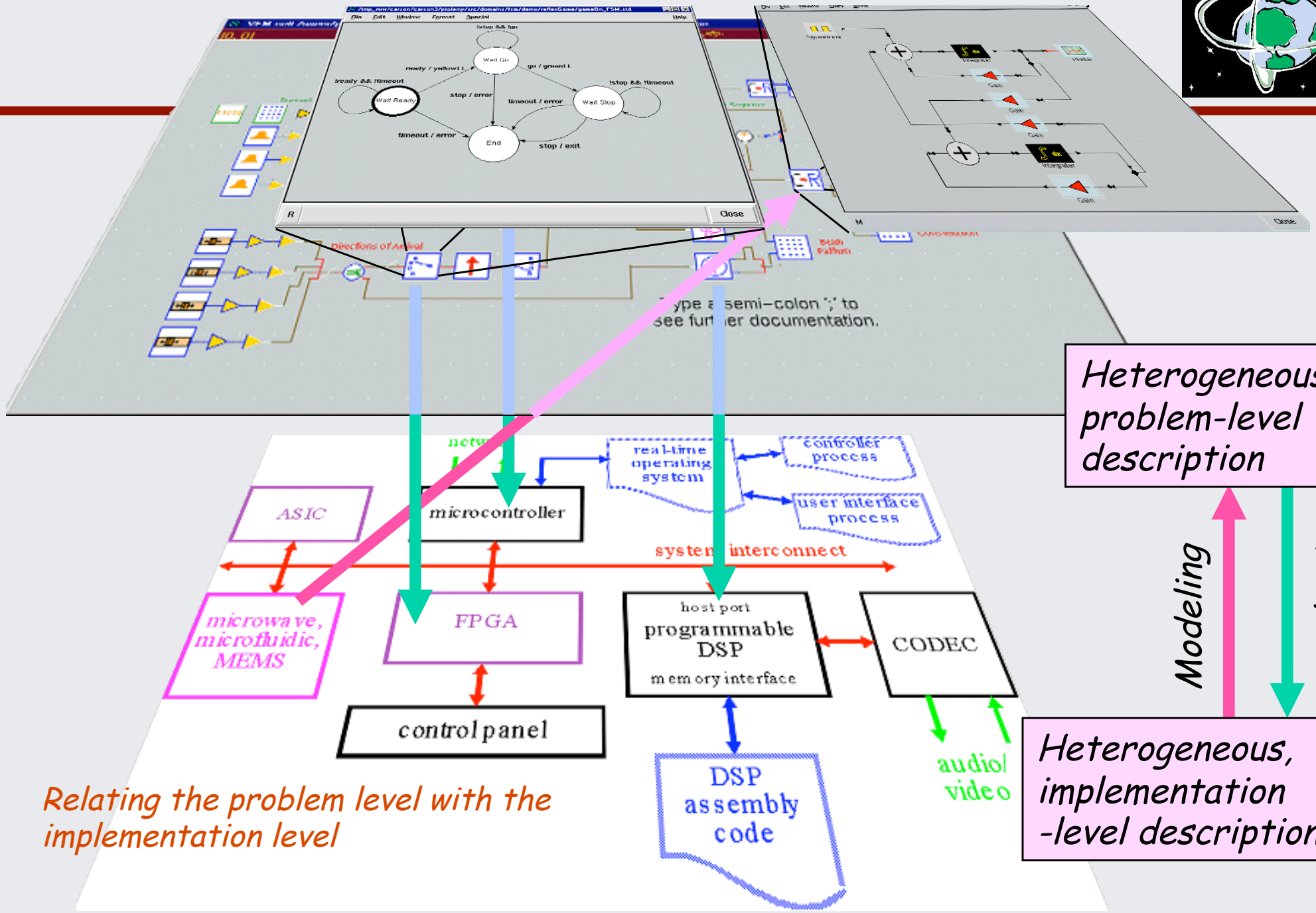
Postdocs, Etc.:

- Joern Janneck, Postdoc
- Rowland R. Johnson, Visiting Scholar
- Kees Vissers, Visiting Industrial Fellow
- Daniel Lázaro Cuadrado, Visiting Scholar

Graduate Students:

- *J. Adam Cataldo*
- *Chris Chang*
- *Elaine Cheong*
- *Sanjeev Kohli*
- *Xiaojun Liu*
- *Eleftherios D. Matsikoudis*
- *Stephen Neuendorffer*
- *James Yeh*
- *Yang Zhao*
- *Haiyang Zheng*
- *Rachel Zhou*





Heterogeneous, problem-level description

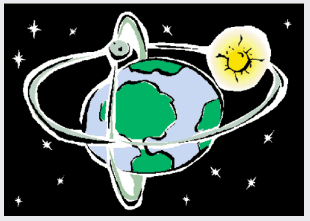
Modeling

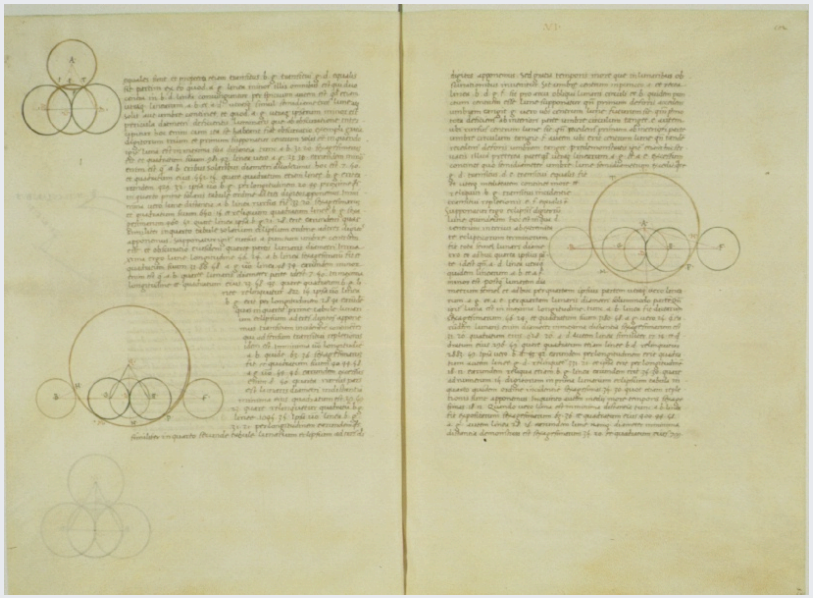
Synthesis

Heterogeneous, implementation -level description

Relating the problem level with the implementation level

Foundations



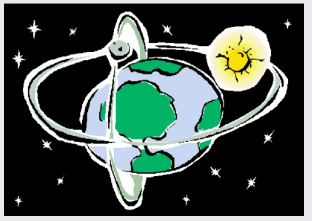


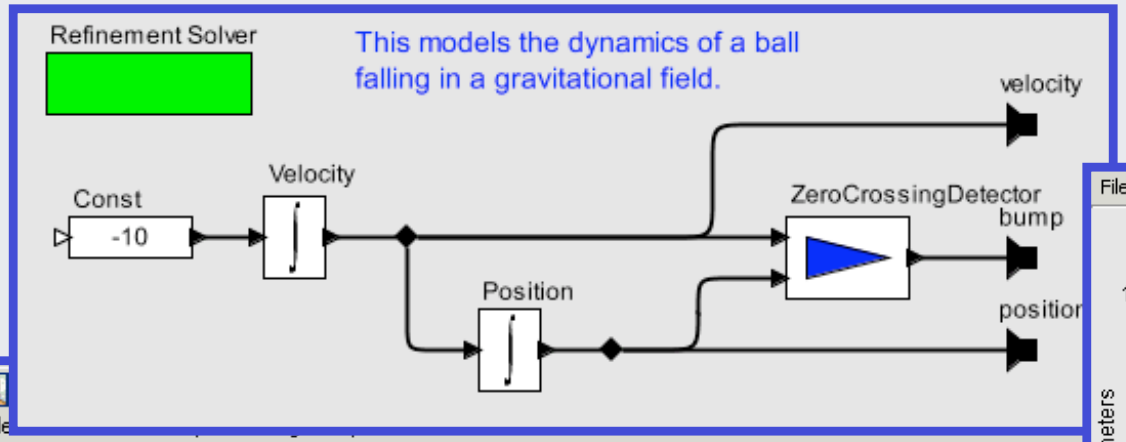
Our contributions:

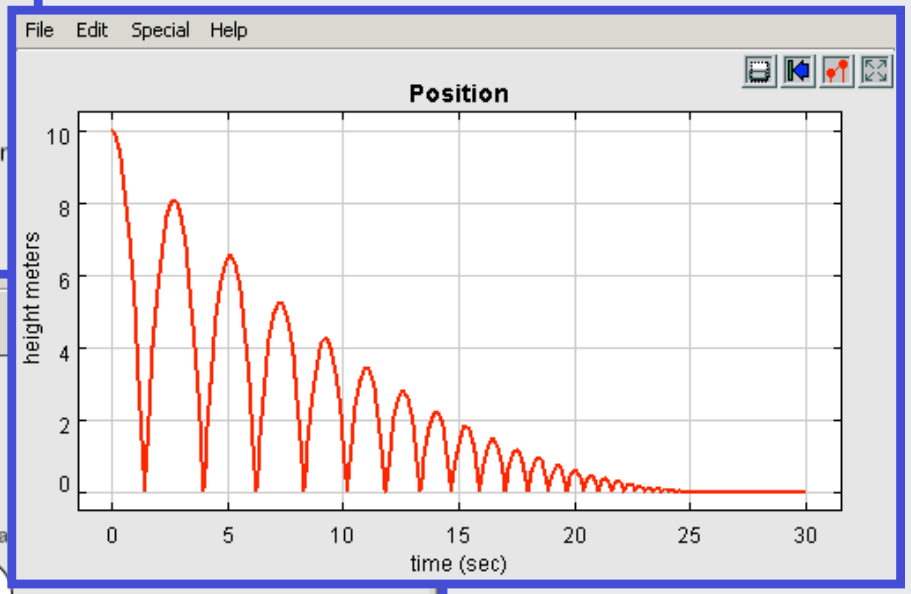
- Behavioral Types
- Domain Polymorphism
- Responsible Frameworks
- Hybrid Systems Semantics
- Dataflow Semantics
- Tagged Signal Model
- Starcharts and Modal Model Semantics
- Discrete-Event Semantics
- Continuous-Time Semantics

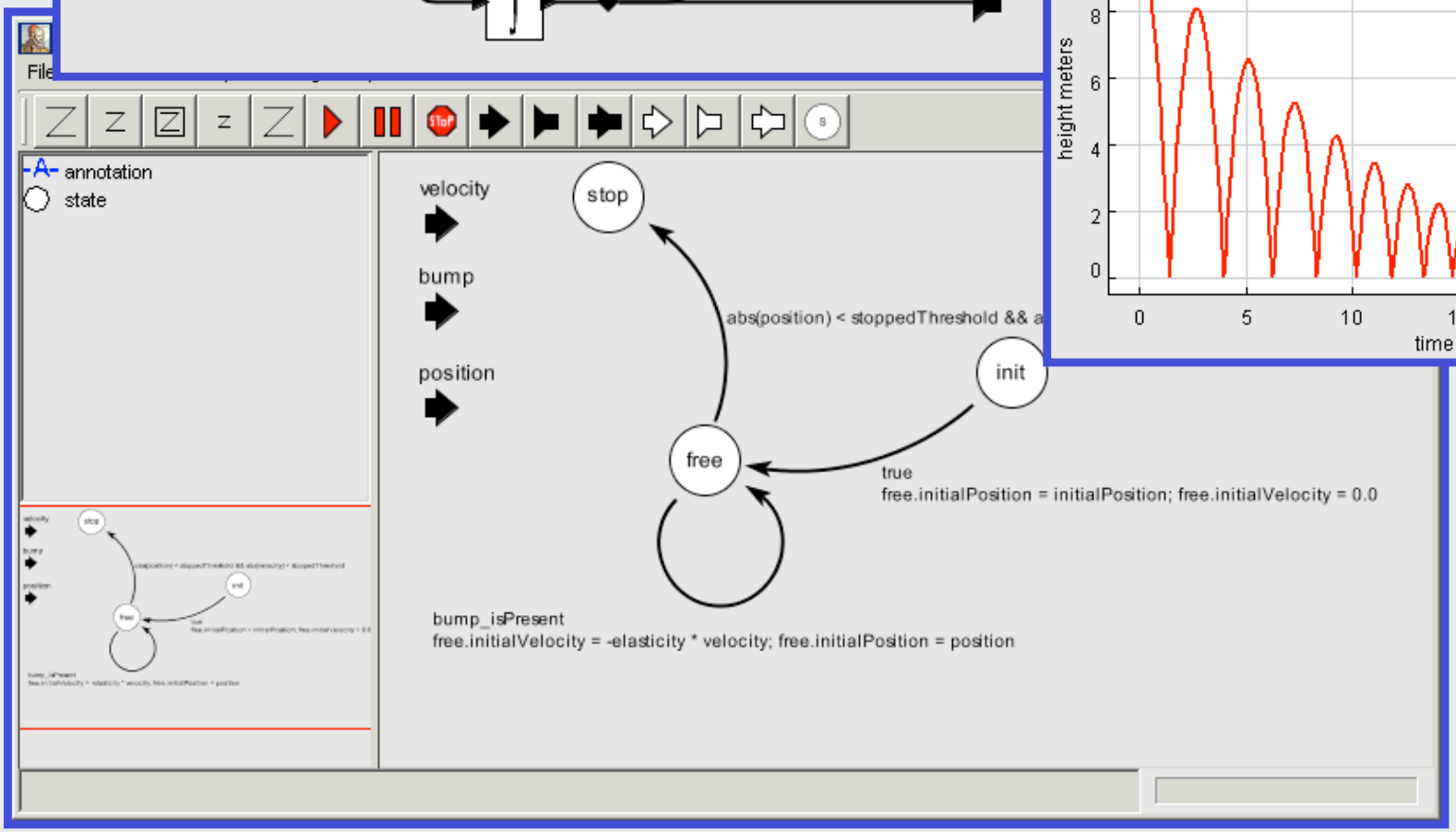
Giving structure to the notion of
"models of computation"

HyVisual – Hybrid System Modeling Tool Based on Ptolemy II, Released Jan. 2003









HyVisual is a targeted tool, designed for hybrid system modeling.

6th 2005

KEPLER: Overview and Project Status

Bertram Ludäscher
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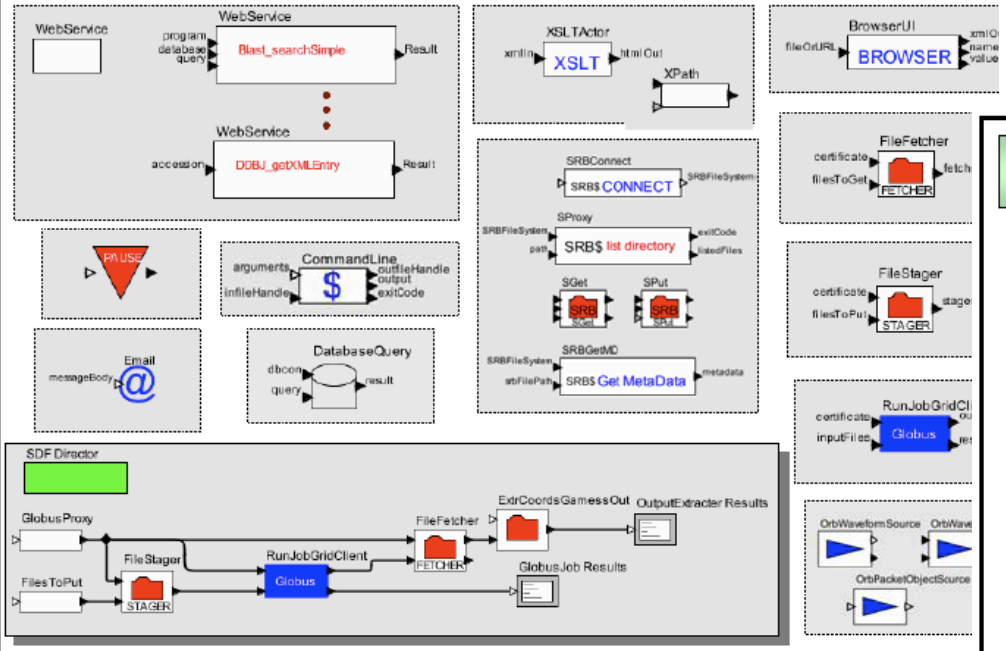
Associate Professor
Dept. of Computer Science & Genome Center
University of California, Davis

Some KEPLER Actors (out of 160+ … and counting…)



6th Biennial Ptolemy Miniconf., May 12th, 2005, Berkeley

Kepler Overview, E

KEPLER/CSP: Contributors, Sponsors, Projects

Ilkay Altintas *SDM, NLADR, Resurgence, EOL, …*
Kim Baldridge *Resurgence, NMI*
Chad Berkley *SEEK*
Shawn Bowers *SEEK*
Terence Critchlow *SDM*
Tobin Fricke *ROADNet*
Jeffrey Grethe *BIRN*
Christopher H. Brooks *Ptolemy II*
Zhengang Cheng *SDM*
Dan Higgins *SEEK*
Efrat Jaeger *GEON*
Matt Jones *SEEK*
Werner Krebs, *EOL*
Edward A. Lee *Ptolemy II*
Kai Lin *GEON*
Bertram Ludaescher *SDM, SEEK, GEON, BIRN, ROADNet*
Mark Miller *EOL*
Steve Mock *NMI*
Steve Neuendorffer *Ptolemy II*
Jing Tao *SEEK*
Mladen Vouk *SDM*
Xiaowen Xin *SDM*
Yang Zhao *Ptolemy II*
Bing Zhu *SEEK*
…

Ptolemy II

www.kepler-project.org

LLNL, NCSU, SDSC, UCB, UCD, UCSB, UCSD, U Man… Utah,…, UTEP, …, Zurich

Collab. tools: IRC, cvs, skype, Wiki: hotTopics, FAQs, ..

Kepler Overview, B. Ludäscher

6th 2005

Growth of the Cal actor language

XILINX®

Programming with actors

Jörn W. Janneck
Xilinx Research Labs

driver application

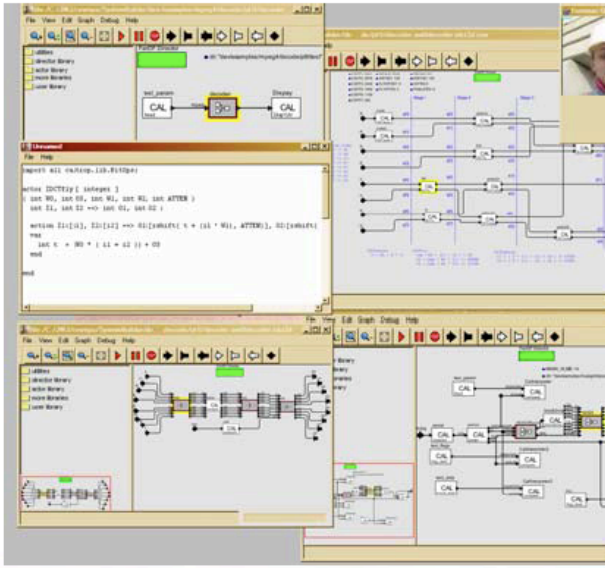
MPEG-4 decoder

metrics

- 60 atomic actors
- 22 atomic actor classes
- 3307 LOC (Cal)
- LOC per actor class between 7 and 2054

actor constructs

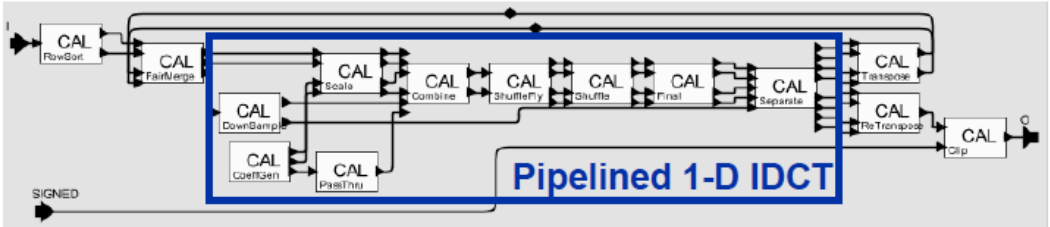
- variable token rates
- static/cyclostatic rates
- data-dependent choice
- test for absence of tokens
  - non-prefix-monotonic actors



code generation

2D-IDCT, version 2

- interleave row and column streams
- pipelined 1D-IDCT
- result:
  - 6 multipliers with 46% utilization
    - more operator re-use costly in terms of operand routing
  - >100 Mhz clock



7th 2007

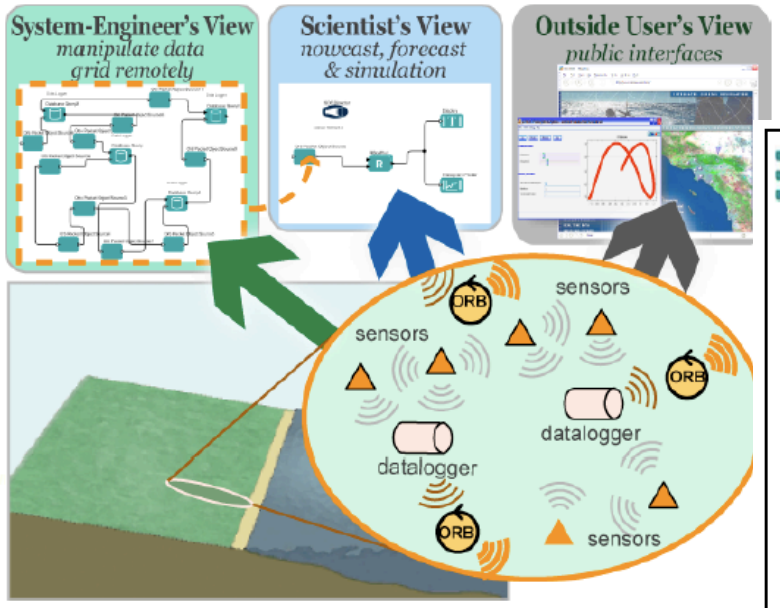
The Kepler Project

Overview, Status, and Future Directions

Matthew B. Jones
on behalf of the Kepler Project team

National Center for Ecological Analysis and Synthesis
University of California, Santa Barbara

REAP breakdown



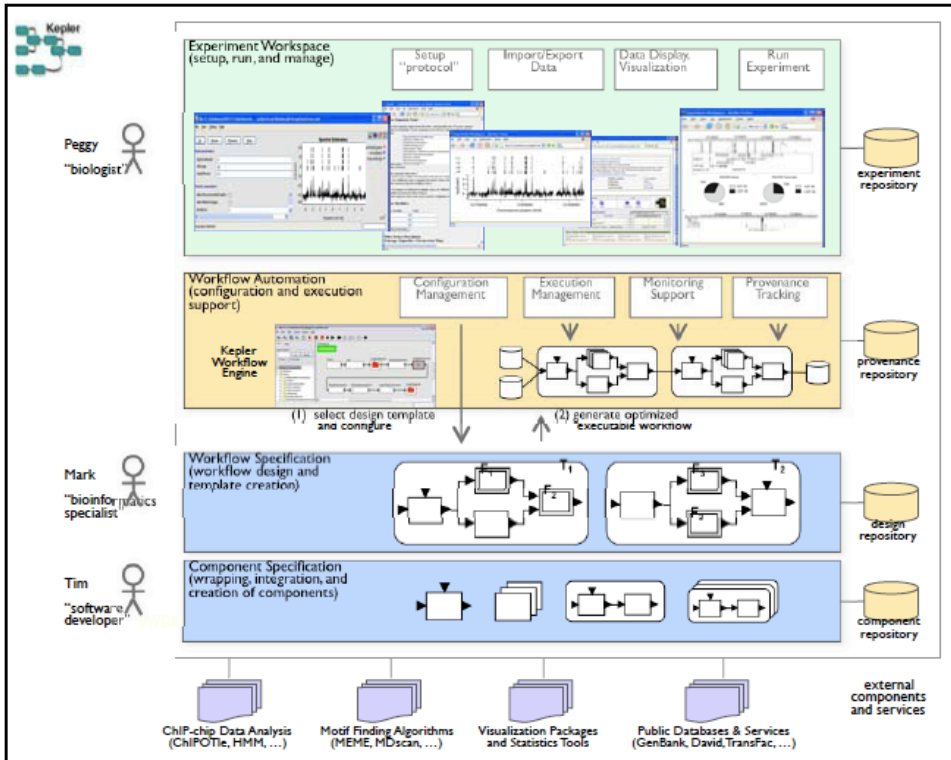


Figure from Bowers and McPhillips

8th 2009

Hugo Andrade (NI)
Christopher Brooks
Dai Bui
Yasemin Demir
John Eidson (Agilent)
Thomas Feng
Shanna Shaye Forbes
Jeff Jensen
Edward Lee
Jackie Leung
Ben Lickly
Isaac Liu
Thomas Mandl (Bosch)
Slobodan Matic
Eleftherios Matsikoudis
Hiren Patel
Stephan Resmerita
Bert Rodiers
Yang Zhao
Jia Zou

Cyber-Physical Systems (CPS)

Where it is going

CPS: Orchestrating networked computational resources with physical systems.

8th 2009

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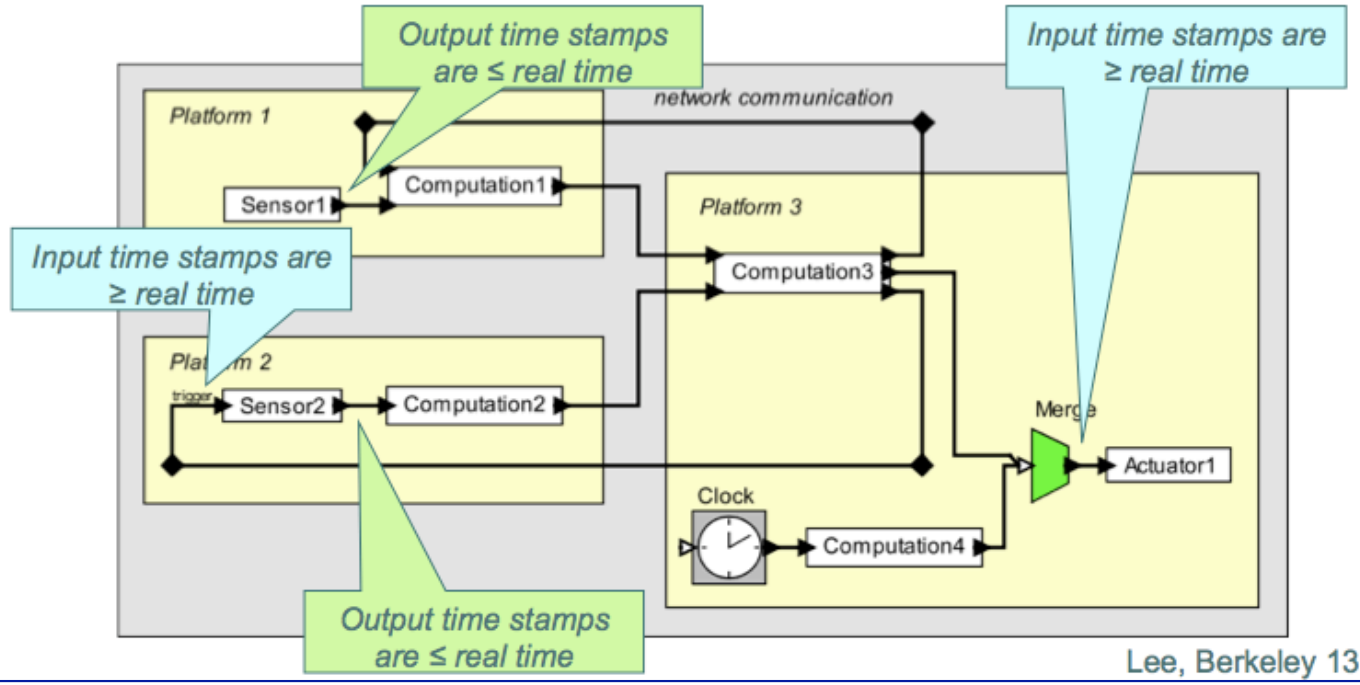
PTIDES: Programming Temporally Integrated Distributed Embedded Systems

Distributed execution under DE semantics, with "model time" and "real time" bound at sensors and actuators.

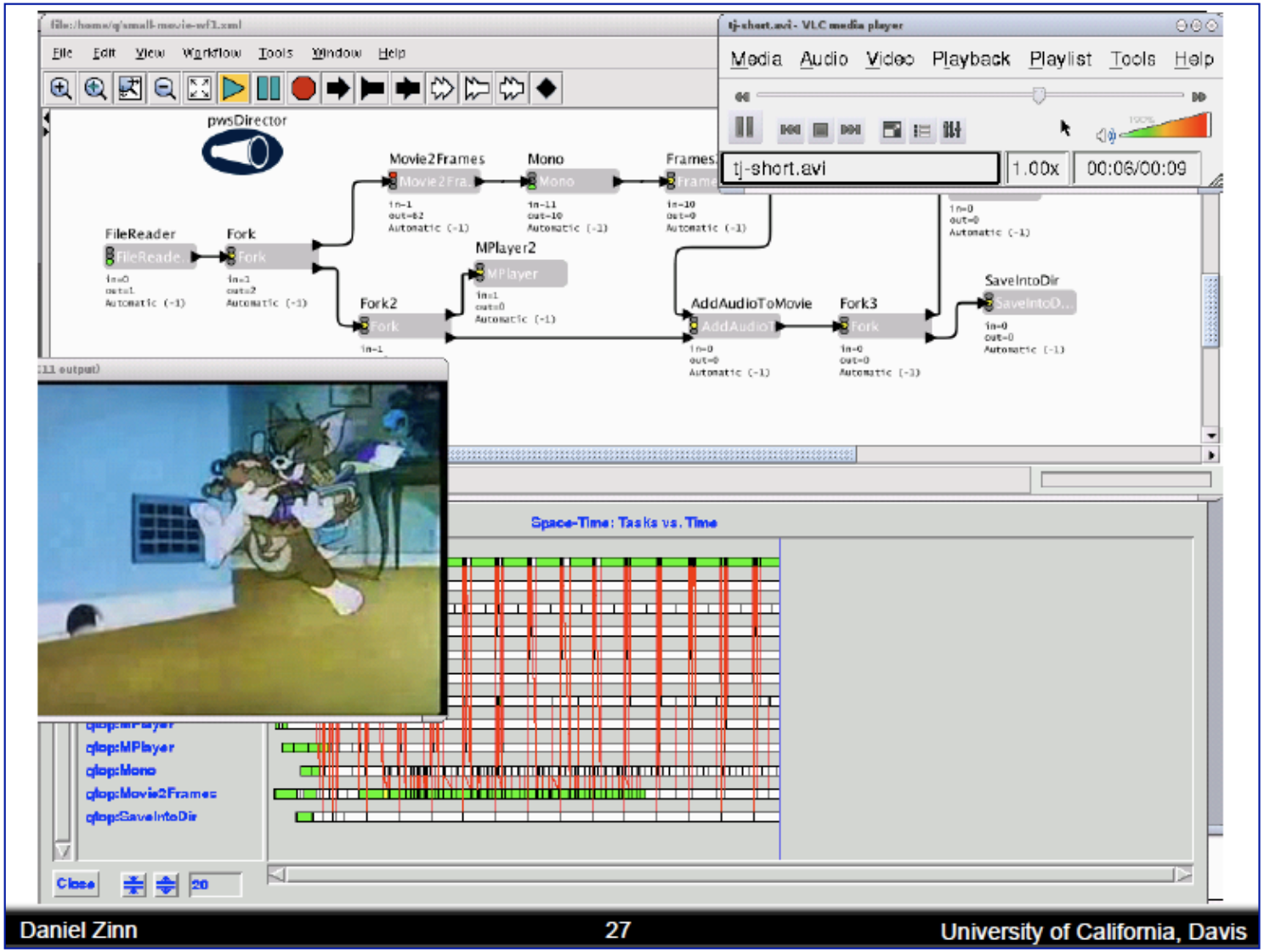


8th 2009

Parallel Virtual Machines in Kepler

Daniel Zinn
Xuan Li
Bertram Ludaescher

UC Davis



9th 2011

Let the show begin!