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INDEX

Sr. No.	Title	Author	Subject	Page No.
1	Cost of capital: an empirical case study of hindustan unilever limited	Dr. Vinod K. Ramani	Accountancy	1-2
2	Self Revolution	Mohanapriya.P	Arts	3-4
3	Wound healing activity of Cestrum elegans	V. Subhaa, Dr. D. Sukumarb, Dr. V. Elangoc	Chemistry	5-6
4	Anti Bacterial Activity of Apigenin 7-0-(6"caffeoyl) neohesperidoside from chrysanthemum indicum	M.Jerome Rozario, Dr.A.John Merina, Dr.V.Srinivasana	Chemistry	7-10
5	Adsorption Studies of Cu (II) and Cr (VI) from metal solution using crosslinked chitosan-g-acrylonitrile copolymer	Shankar.P, Gomathi T., Vijayalakshmi.K, Sudha P.N	Chemistry	11-13
6	An Insight into Derivative Markets: Indian Perspective	Dr. C.Shobha, Dr. T. Hanumantha raya	Commerce	14-16
7	Vision and Planning	Dr. J. K Sehgal	Commerce	17-18
8	An Analytical Study of Employee's Productivity in Some Selected Nationalized Banks of India	Dr. Jyotindra M. Jani, Manish B. Raval	Commerce	19-20
9	New Products of Tourism in India	Dr. M. K. Maru	Commerce	21-22
10	Inventory Management in Sugar Mills - A Comparative Study	Promila	Commerce	23-25
11	Price -Mix Strategy of Jammu and Kashmir Co-Operatives Supply and Marketing Federation Limited in Jammu District of J&K State	Tarsem Lal	Commerce	26-28
12	Warehouse Management Information System: A New Perspective in Supply Chain Management	Dr. Vipul Chalotra	Commerce	29-30
13	A Study on Consumer Satisfaction of Aavin Milk in Salem City	Dr.A.Vinayagamoorthy, Mrs. M.Sangeetha, C.Sankar	Commerce	31-33
14	Hybrid Attribute Selection Process for Decision Tree Based Classification Algorithms	Mr. A. Jebamalai Robinson, Mrs. S. C. Punitha, Dr. P. Ranjit Jeba Thangaiah	Computer Science	34-36
15	Visualizing the validation of UML diagrams	Lavleen Kambow	Computer Science	37-38
16	Effectiveness of coconut palm insurance scheme in the coastal belts of India-A SWOT analysis	Prof. (Dr.) D. Rajasenan, Bijith George Abraham	Economics	39-41
17	An Analysis of the Efficiency of Selected Public and Private Banks in India during 2005-2011	Dr.Dinesh Kumar, Sanjeev	Economics	42-44
18	Measurement of Emotional Development of the Students	Dr. Nivedita K. Deshmukh	Education	45-46
19	A comparative study of effect of method of lecture and dramatization of Marathi teaching	Dr. Nivedita K. Deshmukh	Education	47-48
20	Peer pressure-problems and solutions	V.Vaithyanathan, Dr.P.Sivakumar	Education	49-50
21	Language Anxiety In Indian L2 Learners: Male or Female Learners - Who Scores High?	S. Gandhimathi, Dr.R.Ganesan	Education	51-52

22	Topological Characteristics of ECG Signal using Lyapunov Exponent and RBF Network	Abinash Dahal, Deepashree Devaraj, Dr. N. Pradhan	Engineering	53-55
23	Development of slicing package of solid model for cone and sphere in rapid prototyping	Dineshkumar M. Patel, Prof. P.D.Solanki	Engineering	56-58
24	Hardware modeling Simulation with COSSAP	Krunali Amrutlal Ratanpara, Devendra Soni, Shrenik Rajesh Golwelkar	Engineering	59-61
25	Coordination Of Pss And Statcom To Enhance The Power System Transient Stability	Lalit K. Patel, Kaushik M. Sangada, Sunil S. Changlani , Ankit M. Patel	Engineering	62-64
26	Cooling Performance Analysis of Heat Sink	Mr. Pritesh S. Patel, Prof. Dattatraya G. Subhedar, Prof. Kamlesh V. Chauhan	Engineering	65-57
27	Thermal Modeling and Analysis of Friction Stir Welding	Rankit Patel, Prof. Bindu Pillai	Engineering	68-70
28	Review on shrinkage defect – A case study	Mr. Ravi N. Kalotra, Mr. Gajanan Patange, Mr. J.K. Gohil	Engineering	71-75
29	Stream Function Formulation of Lid Driven Cavity	Mr. Zankhan C. Sonara, Prof. Dattatraya G. Subhedar, Mr. Kartik Patel	Engineering	76-78
30	Implementation of ABT (Availability Based Tariff) - its Treatment & Proceedings	Dilip m.Bhankhodiya, Dipak t. Vaghela	Engineering	79-82
31	Active Filters for Power Quality Improvement	Dipak t. Vaghela, Dilip m. Bhankhodiya	Engineering	83-87
32	Design and Analysis of Air Bearing using Orifice and Feed Hole Pocket	Nileshkumar T. Raval, Prof. M.Y.Patil	Engineering	88-90
33	Drip irrigation technique enhancing water and fertiliser use efficiency in cauliflower	Dr. S.S. Yadav, Dr. R.S. Meena	Engineering	91-92
34	Experimental and FEA Evaluation of Hybrid Joint Strength of Single Lap joint.	S. S. Kadam, P. A. Dixit	Engineering	93-96
35	CFD Analysis of Mixed Flow Submersible pump Impeller	Mitul G Patel, Subhedar Dattatraya, Bharat J Patel	Engineering	97-100
36	EVA: An Innovative Parameter for Shareholders' Wealth Measurement	Shri. Arvind A. Dhond	Finance	101-103
37	Profitability and consistency analysis of Textile Sector in India	Dr. K. S. Vataliya, Rajesh Jadav	Finance	104-107
38	Harmonious Relationship between Art and Music Critical vision (comparison)	Dr. Marwan Imran	Fine Arts	108-109
39	Land Use Pattern and Crop Combination Region in Satara District : A Geographical Study	Dr. Rathod S. B., Mane-Deshmukh R. S.	Geography	110-111
40	Garlic---Benefits and Uses	Dr. Sneh Harshinder Sharma	Geography	112-114
41	An Assessment of Thermal Comfort Zones in Terms of Tourists: A case study of Karveer Tehsil	Mr. Prashant Tanaji Patil, Miss. Mane madhuri maruti, Miss. Mugade Nisha Ramchandra	Geography	115-117

42	Hematological changes due to the impact of Lead nitrate on economically important estuarine fish <i>Mystus gulio</i>	Dr.S.Palani Kumar	Horticulture	118-119
43	Stress Management level in the employees of Manufacture Industries By considering key parameters with reference to Bhavnagar city	Dr. K. S. Vataliya, Adv. Ajay H. Thakkar	Human Resource	120-122
44	The Case of ABC Group-A Case on Performance Appraisal System	Shivani Sah	Human Resource Management	123-124
45	A Study On Performance Appraisal of Employees in Health Care Industry in a Private Multi-Speciality Organization	Dr. C. Swarnalatha, T.S. Prasanna	Human Resource Management	125-126
46	(Upnyas - Jansi ki Rani Laxmibai (vrundavanlal varma)	Dr. Sneh Harshinder Sharma	Literature	127-128
47	"Educational Technology for Professional Development of English Teachers: A Case Study of the College Teachers of English in Jammu Province"	Dr. Wajahat Hussain	Literature	129-130
48	The Reality of Sultana's Dream: A step towards success Rokeya Sakhawat Hossein	Riju Sharma, Ruchee Aggarwal	Literature	131-132
49	Road blocks of Match Industry in Andhra Pradesh: Certain Issues and Concerns	Anuradha Averineni	Management	133-134
50	Government's Assistance Towards the Development of Small Scale Industries in India with Special Reference to Krishnagiri District	B. Mohandhas, Dr. G. Prabakaran	Management	135-140
51	Effects of Role Stress on Employee Job Satisfaction and Turnover	Dr. T.G.Vijaya, R.Hemamalini	Management	141-144
52	"MNP – A major concern of Telecom Operators in Gujarat"	Mohsinali Momin, Dr. Deepak H. Tekwani	Management	145-147
53	A Study on Fiscal Support Provided by Vijaya Bank to Msme in Coimbatore City	Mrs. G. Murali Manokari, Mr. G. Lenin Kumar, Mrs. G. Sathiya	Management	148-150
54	Competencies for HR Professionals	GAYATHRI. M	Management	151-153
55	Cost and Strategic Management - Application, Framework and Strategies for the Growth of Sme Sector	Manisha gaur	Management	154-156
56	Development of Management Education System in India	Mr. Goudappa Malipatil	Management	157-158
57	Study on Volatility and Return of Major Indices of Indian Stock Market with Reference to Sensex And Nifty	Mr. Mukesh C .Ajmera	Management	159-160
58	A Need for an Epitome Shift in Management Education A study on Conceptual Teaching practices	Mrs. Vanishree K. Jamashetti, Mr. Sanjeev Rathod	Management	161-162
59	Personal Social Responsibility – A novel thought	Parul Jain, Dr. N.C Pahariya	Management	163-164
60	Green Marketing – A Consumer's Perspective in the Indian Scenario	Nidhi Srivastava, Preeti Pillai	Management	165-166
61	Challenges and Opportunities of Mobile Banking - An Indian Scenario	Sandhya.Ch.V.L	Management	167-169
62	A pragmatic study of civilizing amortment among The diverse countries	Mr. Vimal P. Jagad, Mr Mukesh .C Ajmera	Management	170-171
63	Celebrity Endorsement in India An Effective Tool of Sales Promotion	Piyush Shah, Dr. N C Pahariya	Management	172-176

64	A Study of Prominent Character Strengths and Their Relationship with Well Being Among Business Management Students	GarimaKamboj, DikshaKakkar	Management	177-180
65	Coffee Consumption in India: An Exploratory Study	Shri. Arvind A. Dhond	Marketing	181-183
66	Applicability of Retail Service Quality Scale (RSQS) in India	M. Ramakrishnan, Dr. Sudharani Ravindran	Marketing	184-186
67	Account Holders perceptions towards Self Service Technologies: a study of selected Private Sector Banks	Dr A Kumar, Prof Ankur Gangal	Marketing	187-189
68	Impact of Sales Promotion on Sales figures of Select International FMCG Brands	Dr.Sharif Memon	Marketing	190-193
69	Factors Affecting Green Product Design: Marketing Professional's Perspective	D. S. Rohini Samarasinghe	Marketing	194-196
70	The Impact of 'Ambience' and Variety on Consumer Delight: A Study on Consumer Behaviour in Ahmedabad	Dr A Kumar, Prof Vineeta Gangal	Marketing	197-200
71	Co-Relation of Social Justice with Human Rights: A Review	Dr. Monica Narang	Marketing	201-202
72	Study of Iron Status and Free Radical Activity in Plasmodium Falciparum and Plasmodium Vivax Malaria Infection	Sangita M. Patil, Ramchandra K. Padalkar	Medical Sciences	203-205
73	GOAL SETTING TENDENCIES, COMMUNICATION SKILLS AND WORK MOTIVATION VIS-À-VIS AGE DIFFERENCE – A STUDY ON PUBLIC SECTOR ORGANIZATION	Dr. Swaha Bhattacharya, Dr. Monimala Mukherjee	Psychology	206-208
74	Role of NGOs in Social Mobilization in the context of SGSY	Dr.Veershetty C. Tadalapur	Sociology	209-211
75	Age at menarche and its secular trend in rural and urban girls of bathinda district	Jyoti Sharma, Dr. Ajita	Sports Science	212-213
76	Effect Of Resin Finishing On Stiffness And Drape Of Khadi Fabric	Dr. Suman pant, Ms. Noopur Sonee	Textiles	214-216



Hardware modeling Simulation with COSSAP

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 *** Shrenik Rajesh Golwelkar

*, **, *** Assistant Professor, Amc Engineering College, Bangalore

ABSTRACT

The paper describes the integration of an experimental test system for digital signal processing hardware into a data flow driven system simulation environment. The integration enables running simulations with actual hardware components in the loop (hardware modeling). The implications of data flow driven simulations to hardware modeling are discussed as compared to hardware modeling in conjunction with event driven simulation. The experimental setup is described and results for the achieved simulation speedup are given.

INTRODUCTION

The integration of telecommunication systems on silicon is currently facing major challenges due to the fast progress in technology. Today, managing design complexity has become the limiting factor rather than circuit technology. Thus advanced design methodologies have become a pre-requisite to be capable of designing VLSI systems which make ancient use of the technological opportunities. As one consequence, the development of heterogeneous simulation environments (e.g. mixed mode simulation) has recently attracted increased attention [1] [4].

As a facet of heterogeneous simulations we discuss in this paper simulations which employ actual hardware components. In the sequel the resulting simulation is called hardware in the loop simulation and the modeling technique hardware modeling. Hardware modeling was introduced by Widdoes in 1984 [6].

Experiments have proven that data flow simulation provides speedups in excess of one order of magnitude as compared to event driven simulation which is predominantly used on lower levels of abstraction [1,5].

There are several advantages resulting from the use of digital signal processing hardware whose input is computed by a simulation program running on a workstation and whose output is read in by the same program:

Authenticity:

The piece of hardware is the same as in the target system this guarantees perfect authenticity of the simulation results as far as the included piece of hardware is concerned.

Modeling:

In case hardware components are purchased from external suppliers, system development is possible even with the basic black-box knowledge about these components since this information is sufficient for hardware modeling.

Well Defined Verification Environment:

Hardware components can be varied against the specification in a well defined environment. The data fed to the hardware board can either be straightforward for debugging purposes or very complex resulting from comprehensive system model implemented in the simulation system.

HARDWARE MODELING AND DATA FLOW SIMULATION

We will briefly introduce the concept of a signal in a data flow driven simulation in this section to prepare the ground for a clear discussion of advantages and limitations of hardware

modeling in the context of a data flow driven simulation.

Signal Paradigms

Hardware modeling requires the generation of all physical signals that are required to run the hardware controlled by the simulation. A signal paradigm defines the relation of the value of a signal to the on going (virtual) simulation time At which time a simulation model is fired to compute new values of its output signals (module scheduling).

Different signal paradigms reject different levels of abstraction of a physical signal which exhibit a value at every point of time and are thus not generally representable in a digital computer.

Table 1. Signal Paradigms

Signal paradigm	Signal/time relation	Scheduling scheme	Used in
Event driven	Value & time of change	Change of an input signal	VHDL etc
Data flow driven	Only sequence of value	All necessary input samples value	COSSAP etc.

Event driven simulations are based on the idea that a signal can be described by a sequence of events which describe a signal change. The fired model then computes the new values of its output signals. The associated events are inserted into an event table which is managed by the kernel of the simulator.

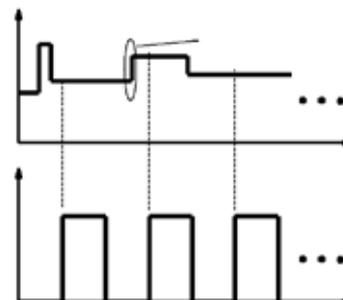


Fig. 1: Event driven signal representation

Data flow simulations, in contrast, do not keep track of the time. Signals are represented merely by sequences of values. The sequence does not even necessarily have an interpretation on the time axis. The values may equally well describe for example signals in the frequency domain or asynchronous signals [13].

In contrast to event driven simulation control signals are not required to model systems in a data flow driven simulation since the sequence of values is sufficient to drive most algorithms in digital signal processing. However, whenever interfacing to real world signals is required an interpretation over time must be added to the data flow signals.

Interfacing to Physical Signals

Physical signals are obviously not directly interfaceable to a data flow signal since they continuously exhibit a value at each time instant. Consequently sampling of these signals is required to interface to the simulation.

Digital hardware usually either runs at a fixed clock rate which in turn defines at what time meaningful signal values at the ports are present or establishes explicit handshaking schemes. Such devices .As a advantage of the latter case multiple instances of the device in a simulation can be handled if the stimuli history is stored for each instance. Clearly, supporting dynamic components and multiple instances leads to very complex interfaces with high speed memory, programmable clock sources etc.

Interface Model Requirements

It is of course desirable to provide a hardware model at the system level to the design engineer which resembles the hardware in a form that allows easy integration into the system simulation setup.

A primitive model 1 in COSSAP is a model written in a programming language like C which communicates via well defined interface functions to other models. In order to be easy and convenient to use, the interface model should comprise the following functionality:

Universality:

The interface model should be parametrizable to serve arbitrary hardware hooked on the hardware interface.

Initialization:

The interface model should provide a pos-sibility to initialize the hardware and the hardware interface, since explicit signal generation for initialization in the simulation setup can be very awkward.

Signal Hiding:

The interface model should be capable of applying simple clock systems, and constant signal values to the hardware without requiring equivalent data flow signals, since these signals are often not required for the remaining simulation.

A SAMPLE SOLUTION

We developed a primitive model for the system simulator COSSAP and a proprietary hardware interface at our institute which allows us to model hardware mainly for systems and ASICs developed in our institute.

ISS Test Hardware

As was elaborated earlier the complexity of the interface hardware is determined to a large degree by the hardware which is to be included into the simulation setup. The interface complexity may range from simple programmable parallel interface to complex hardware which may be required to satisfy absolute timing requirements

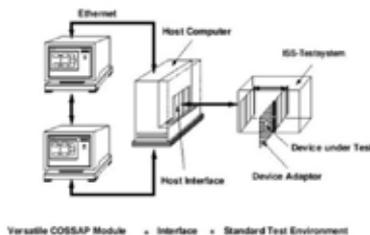


Fig. 2: ISS Test Hardware

The test hardware at our institute was developed for low cost testing of fully synchronous digital hardware. The test hardware consists of 160 programmable interface pins, a

Programmable clock generator which provides three clock signals of up to 50MHz frequency and a programmable cycle counter which allows to apply clock bursts of up to 224 cycles to the device under test

A Versatile Interface Model

A versatile COSSAP module has been developed which is configurable for any device adaptor. The module takes a data set for module configuration [16]. Hardware initialization is performed in the aforementioned manner.

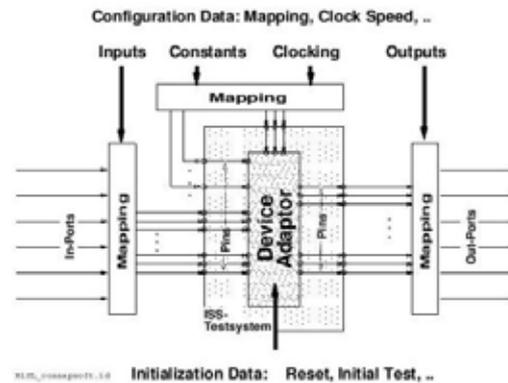


Fig. 3: Structure of the COSSAP Module

The data set which configures the model has four parts which establish input mapping, output mapping and interpretation, constant signal specification and clock specification. A mapping specification establishes a mapping between a data flow signal (of type integer) at port number N to one or more bits of the hardware interface.

Performance

In the following we discuss as an example the simulation of the experimental fully digital 100MBit/s receiver DIRECS [13], which consists of 6 ASICs. Figure 6 shows the hierarchical software model of the receiver which consists of several primitive models.

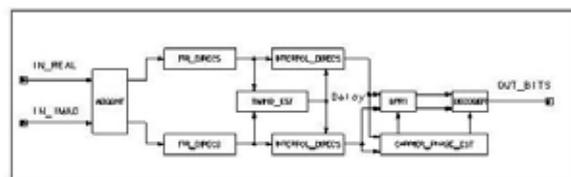


Fig. 4: Hierarchical COSSAP Model of DIRECS

It is worth mentioning here that the model in Figures 6 has different data rates at inputs and outputs since a digital receiver usually requires oversampling of the input signals.

By runtime profiling of our software, it was found that the bandwidth of the host interface limits the simulation throughput of our example. However, even in the small simulation setup described above, the interface software to our testing environment consumed only 20% of the simulation runtime which shows that optimization of this interface would not result in large speedups. After all, the verification of the receiver was made possible down to bit error rates of 10⁻⁷ due to a tenfold increase in simulation efficiency as compared to the software models of Figure 4. The resulting number of 250 million clock cycles (17 Gigabits of data) shows clearly why playing stimuli historys was not a viable solution for our application.

CONCLUSION

While hardware modeling in conjunction with event driven simulation is a commercial reality, our experimental setup shows that hardware modeling is possible in conjunction with data flow driven simulations. This is due to the fact that we deal with the sequence of meaningful values rather than timed signals. We did not support bidirectional ports. These restrictions react our application domain which is in the loop

simulation of digital signal processing ASICs. An experimental hardware modeling solution for the simulation system COS-SAP was developed in conjunction with a proprietary test environment for integrated circuits and VLSI systems. This solution provides the full functionality for hardware modeling of the hardware components at high simulation speed and low cost.

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