i-MOS *i*nteractive Modeling and Online Simulation Platform

A Platform for Compact Model Sharing

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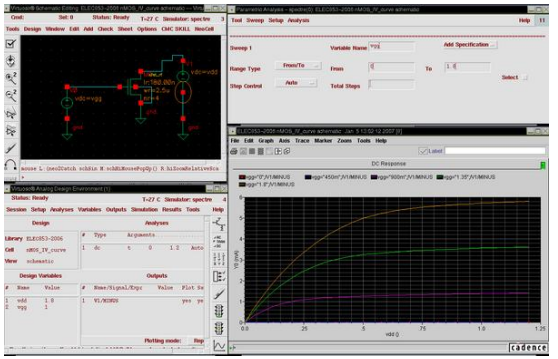
THE ROLE OF COMPACT MODELS

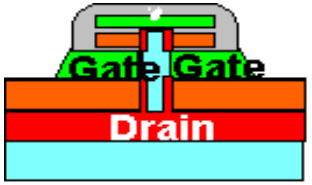
❖ Device → Models → Simulator → Applications

Scaling MOSFET

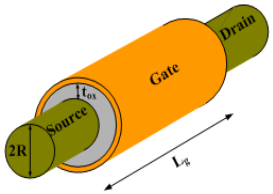
VBIC
ACM
USIM
BSIM
HiCUM
Mextram
HVEKV
HiSIM
PSP
MM20

Eldo
Spectre
ADS
Smash
HSIM
APLAC
Nanosim
HSPICE
Golden Gate
AMS

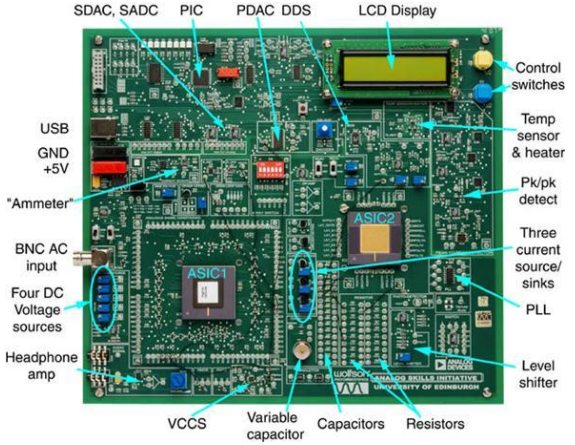




Multi-Gate MOS



Nanowire MOSFET



CURRENT MODELING INFRASTRUCTURE

Technologist

Modelers

Designers

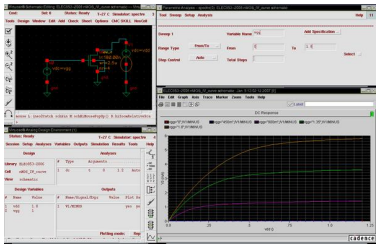
Applications

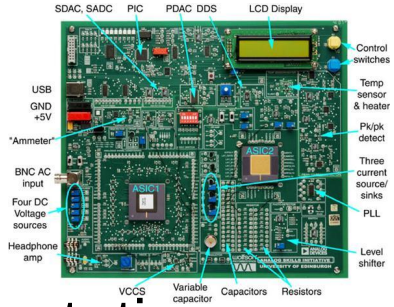
Model 1

Model 2

Model 3

Circuit Simulation





Experimental data, Parameter Extraction

Coding, Testing, implementing to a simulator

Implementation, Compiling, Evaluate Models, obtain parameters

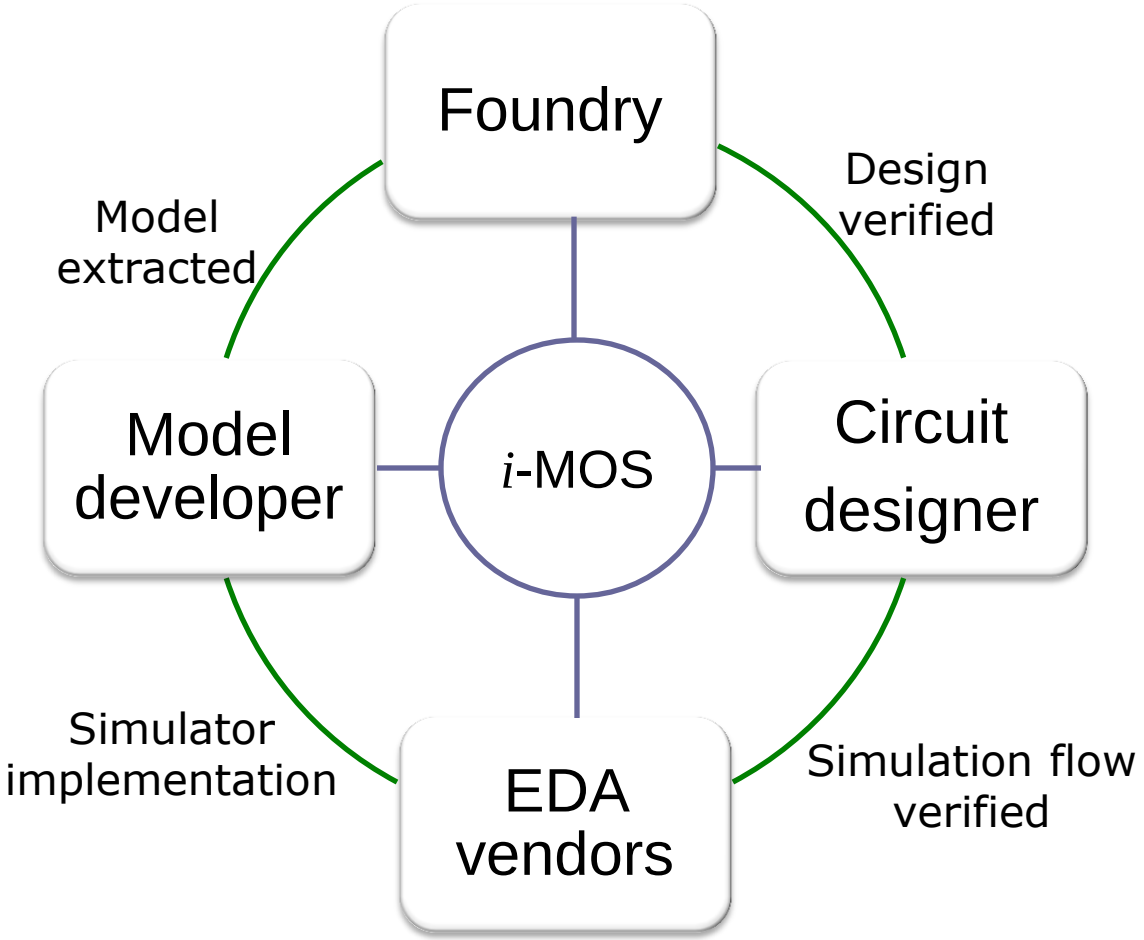
STATUS OF PUBLISHED MODELS

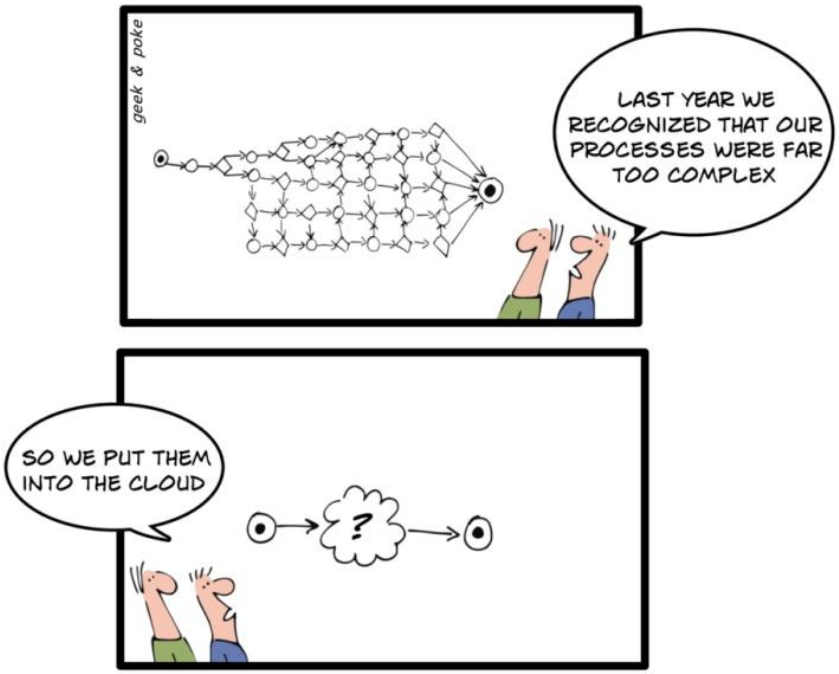
- Some only describe a single quantity (like threshold voltage) rather than a complete model
- Some have implicit functions that require numerical solution
- Some models have discontinuities between different section of the characteristics
- Some have poorly behaved derivatives
- Some do not have charge and capacitance model
- Some do have an explicit parameter set
- Convergence issues of most models are not tested
- No follow-up after publication

A REVOLUTIONARY DISTRIBUTION CONCEPT

- The App store has significantly shorten the distance between programmer and users since July 11, 2008
- Can we have an App store for compact models?

AN APP STORE FOR COMPACT MODELING

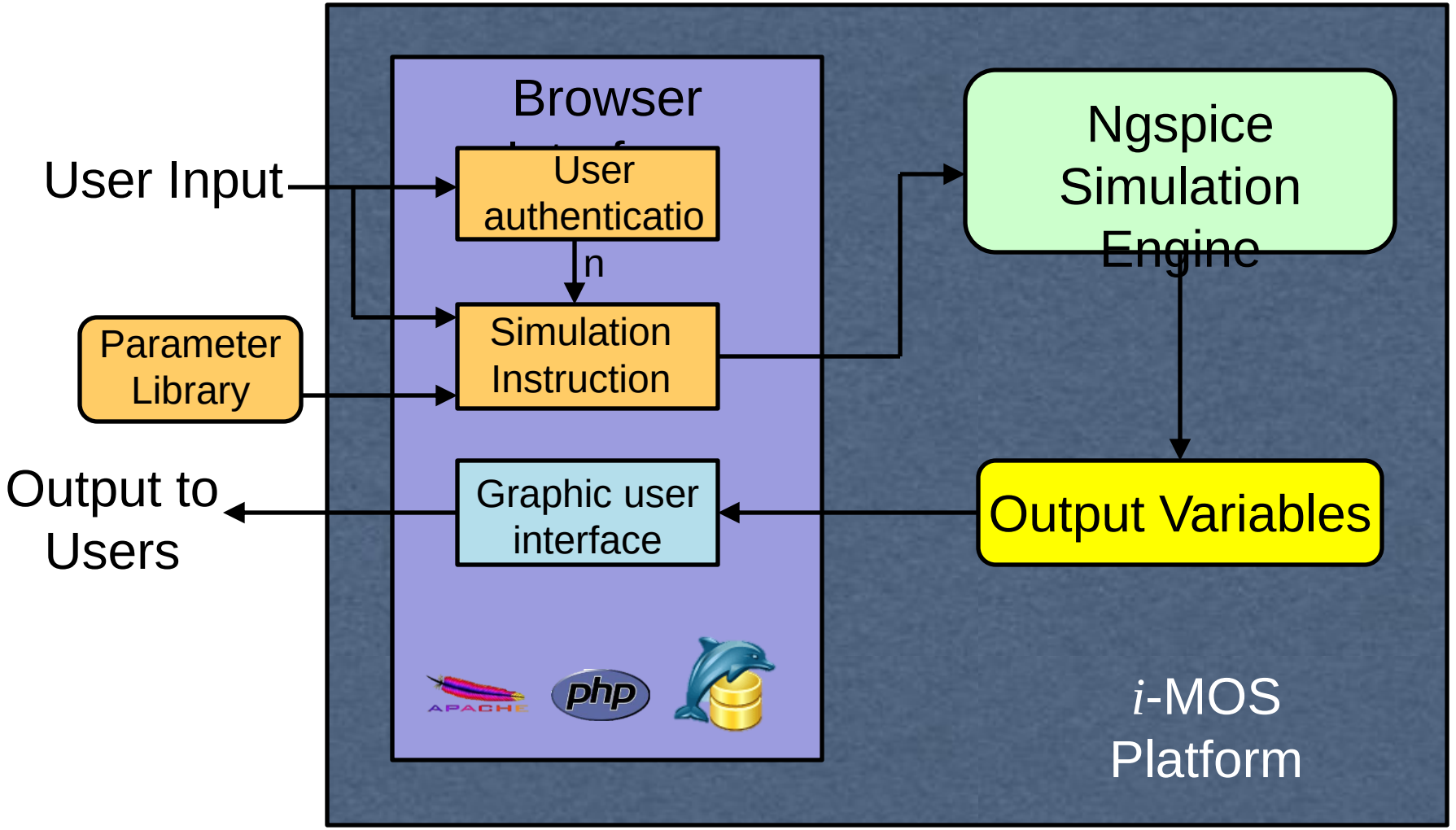




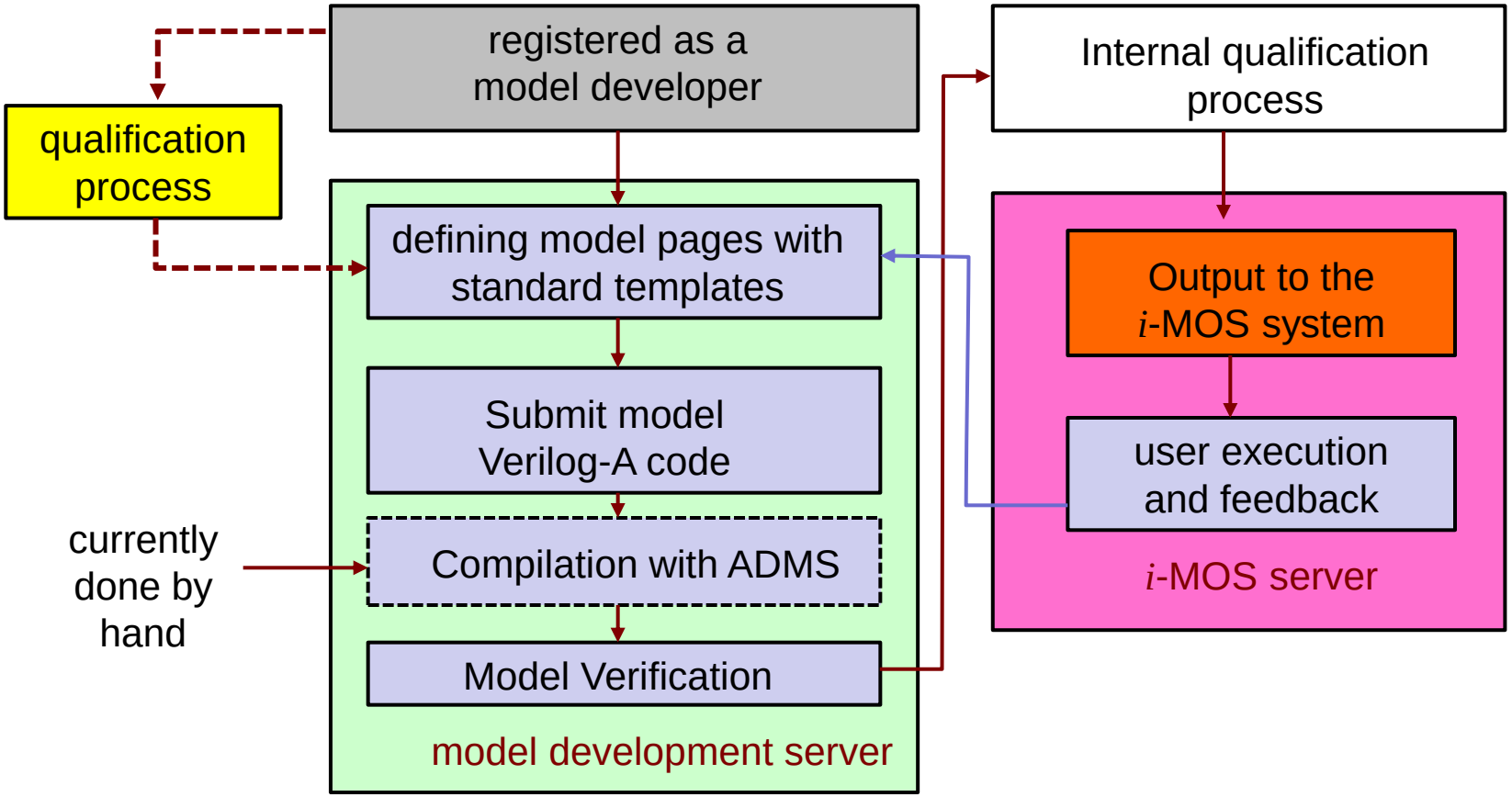
THE *i*-MOS PROJECT

- It stands for interactive Modeling and Online Simulation
- Intended to be a social network for the compact modeling community including both developers or just users
- Provide a platform for model developers to distribute their models
- Provide a platform for users to evaluate models
- A place to discuss modeling related issues
- A source for updated modeling activities
- It runs under a user driven model with light moderation

COMPONENTS OF *i*-MOS

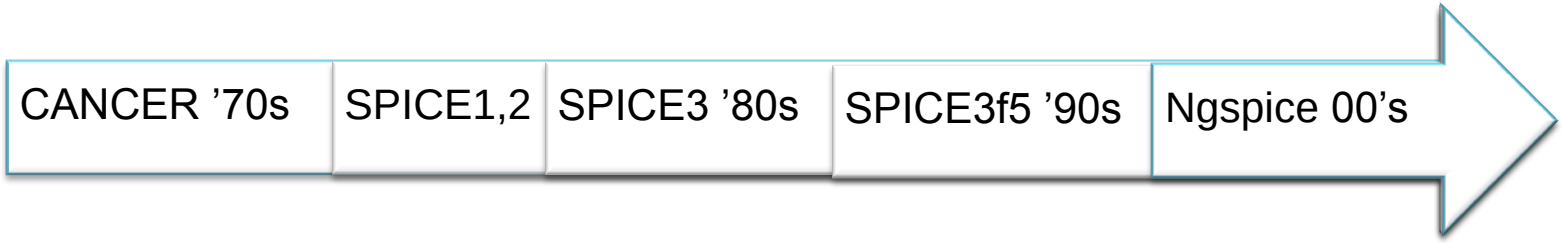


MODEL IMPLEMENTATION

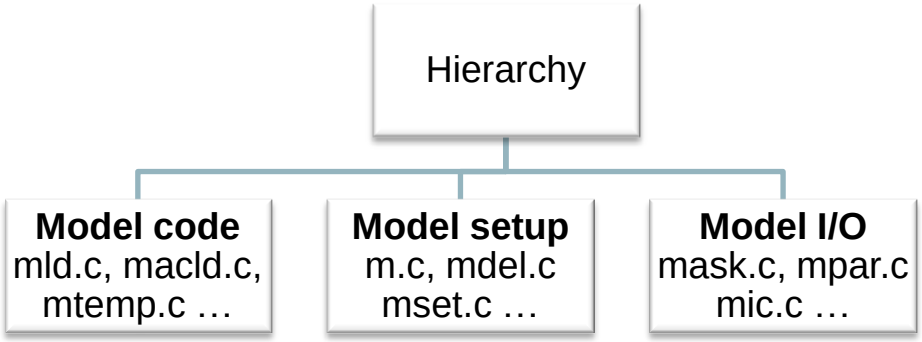


THE NGSPICE ENGINE

- From de facto standard simulator SPICE



- Many standard device models have already been included
- It has a specific C interface



THE ADMS VERILOG-A COMPILER

- Verilog-A has become the standard modeling language
  - Developer friendly
  - Interpreted code has lower efficiency than C-code
  - Widely used for new models
- ADMS
  - Convert Verilog-A to C-code
  - Partial derivation for Jacobian matrix
  - Model/instance setup API
  - Similar efficiency to hand code

THE NGSPICE INTERFACE

```
<admst:text format="IFparm $(module)mPTable[] = {\n"/>
<admst:join select="variable[parametertype='model' and input='yes']"
separator=",\n">
 <admst:choose>
  <admst:when test="[type='real']">
   <admst:value-of select="name"/>
   <admst:value-of select="name"/>
   <admst:value-of select="name"/>
   <admst:text format="
IOP(&quot;%s&quot;,$(module)_model_%s,IF_REAL,&quot;%s&quot;)"/>
  </admst:when>
  <admst:when test="[type='integer']">
   <admst:value-of select="name"/>
   <admst:value-of select="name"/>
   <admst:value-of select="name"/>
   <admst:text format="
IOP(&quot;%s&quot;,$(module)_model_%s,IF_INTEGER,&quot;%s&quot;)"/>
  </admst:when>
  <admst:otherwise>
   <admst:fatal format="parameter of type 'string' not supported\n"/>
  </admst:otherwise>
 </admst:choose>
</admst:join>
<admst:text format="\n};\n"/>
```

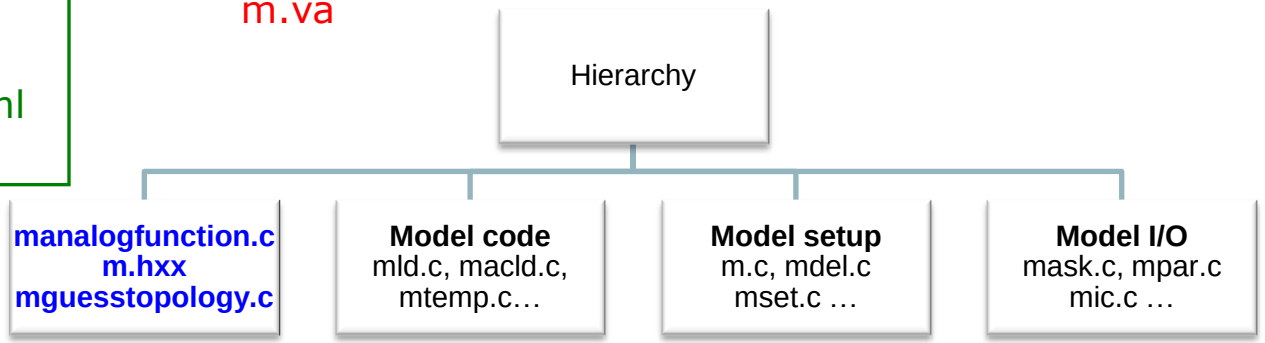
ngspiceMODULE.c.xml

```
parameter real phisb = 0 from (-inf:inf)
  `P(info="Barrier Height");
parameter real rs = 0 from (-inf:inf)
  `P(info="Source Access resistance");
parameter real rd = 0 from (-inf:inf)
  `P(info="Drain Access resistance");
parameter real beta = 20 from (-inf:inf)
  `P(info="Drain coupling coefficient");
parameter real Cc = 7e-12 from (-inf:inf)
  `P(info="Coupling capacitance");
parameter real mob = 1 from (-inf:inf)
  `P(info="Scattering parameters");
parameter real Csubfit = 1 from (-inf:inf)
  `P(info="Vfb adjustment parameter");
parameter real Cp = 0 from (-inf:inf)
  `P(info="Parasitic capacitance");
```

m.va

```
IFparm cnt_mPTable[] = {
IOP("pnp", cnt_model_pnp, IF_INTEGER, "pnp"),
IOP("npn", cnt_model_npn, IF_INTEGER, "npn"),
IOP("phisb", cnt_model_phisb, IF_REAL, "phisb"),
IOP("rs", cnt_model_rs, IF_REAL, "rs"),
IOP("rd", cnt_model_rd, IF_REAL, "rd"),
IOP("beta", cnt_model_beta, IF_REAL, "beta"),
IOP("cc", cnt_model_Cc, IF_REAL, "Cc"),
IOP("mob", cnt_model_mob, IF_REAL, "mob"),
IOP("csubfit", cnt_model_Csubfit, IF_REAL, "Csubfit"),
IOP("cp", cnt_model_Cp, IF_REAL, "Cp")
};
```

m.c



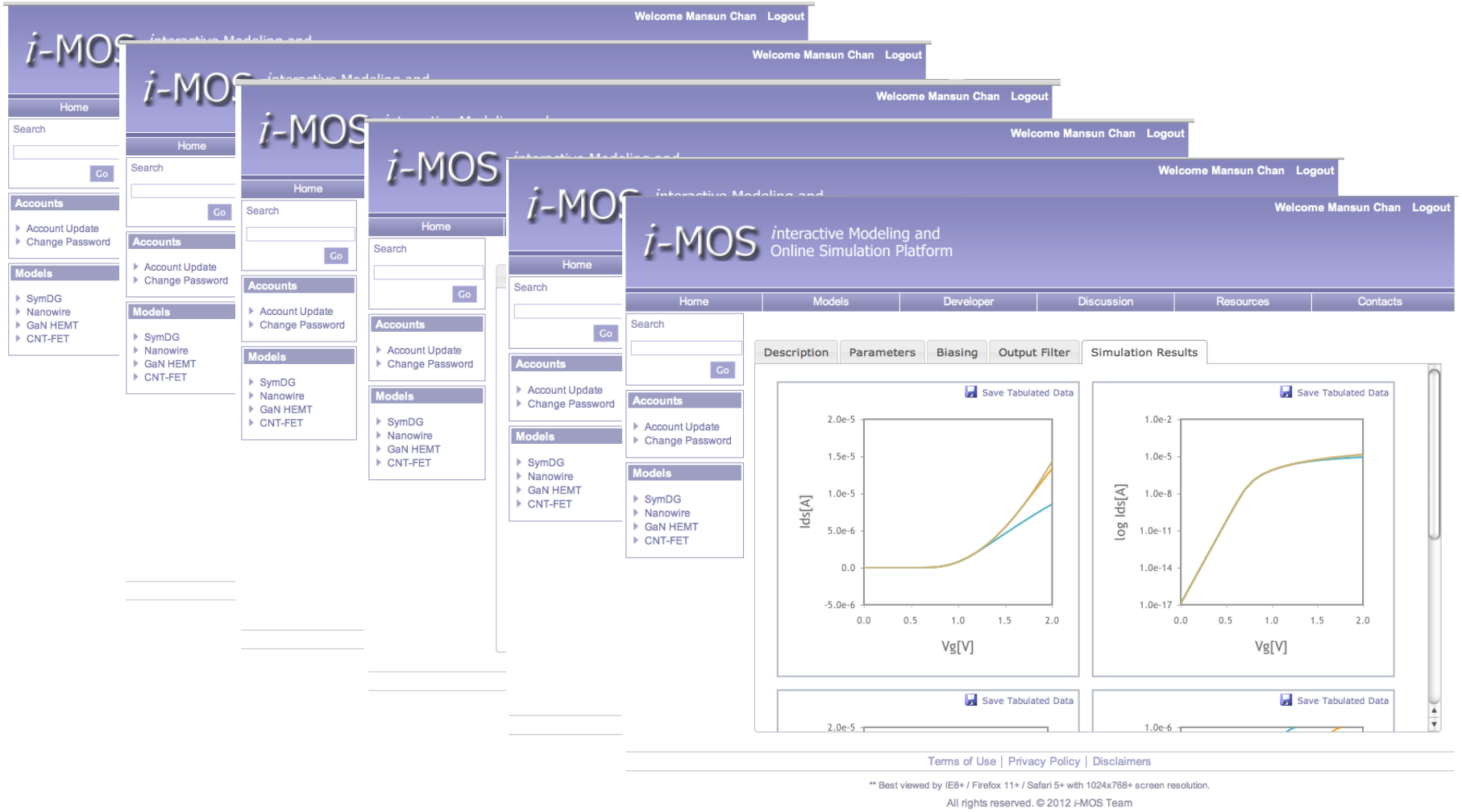
admsXml –I(srcdir) –I(srcdir)/admsva $(srcdir)/admsva/m.va –e ngspiceMODULEtempale.xml

- An authoring kit is being develop to automate the process

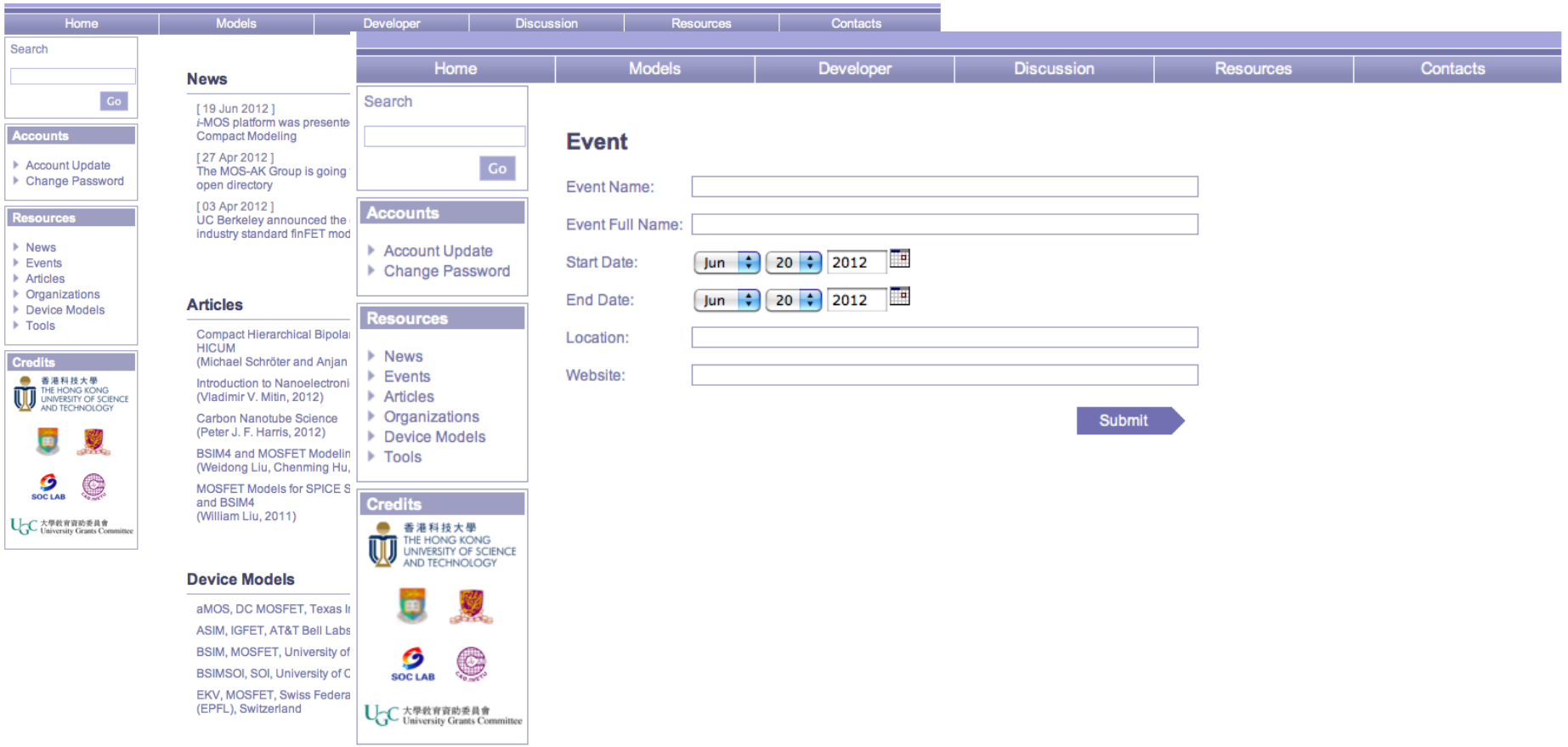
BENEFITS TO MODEL USERS

- *i*-MOS made many device models available for early access without the need of compilation and execution on a local machine
- Run simulations and do demonstrations anywhere
- Able to directly compare the completeness and performance of different models
- Uniform GUI with low learning barrier
- Come with standard parameters, benchmark, test circuits
- One stop service to model documents and modeling activities

i-MOS SIMULATION INTERFACE



MODELING RESOURCES



- You are welcome to post your modeling activities on *i*-MOS

BENEFIT TO MODEL DEVELOPERS

- Provide a standard on the requirements of a model, including I-V, Q-V, first derivatives, continuity, smoothness etc.
- Provide a simple authoring tool to interface the model to a circuit simulation engine directly
- Provide a simple and standard user interface to distribute models to users
- Facilitate the user feedback process for model refinement and improvement
- Promote interaction between model developers and users through various channel of discussion

MODELS IMPLEMENTED IN CURRENT SYSTEM

Device Type	Group	Availability
Symmetric Double Gate MOSFET	HKUST/Peking University	Online
Silicon Nanowire Transistor	HKUST/Peking University	Online
AlGaN HEMT	Tsinghua University	Online
CNT FET	Arizona University	Online
CNT FET	Stanford University	Online
Tunneling FET	HKUST	Online
Phase Change Memory	HKUST	In Progress

- We are encouraging model developers to post their models here

BENEFITS TO EDA VENDORS

- Provide early access to new device models
- Evaluate and compare models under the same platform using standard GUI
- Collect user feedback to obtain popularity of various models based on model rating
- Provide a platform to communicate with model developers
- Provide parameter extraction service for a given model from foundry data
- Gain access to parameter sets from various sources (either as transparent data or blackbox plugin)

ISSUES TO RESOLVE

- Current version of ADMS only support a subset of Verilog-A syntax
  - V(..) <+ xxx not supported
  - I (..) probes not supported
  - For loop not supported

```
//allowed in ADMS
I (a,b) <+ V (a,b) ) / R;
//not allowed in ADMS
V(a,b) <+ I (a,b)*R;
```

- XML script of ADMS poorly documented
- Human interface need for some time before all the tools are ready

OTHER SERVICES TO BE LAUNCHED

- Automated Model Authoring kits
- Modeling rating and commenting
- Discussion group and professional networking
- Parameter extraction
- Standard parameter set
- Standard test results
- Online simulation (A very important feature)
  - Phase I, input by submitting netlist text file
  - Phase II, complete circuit simulation GUI

PLEASE TRY OUT OUR SERVICE

- Please visit the following site:

http://i-mos.org

- You will be able to try out our service after a simple and free registration
- It is not perfect at present stage and we appreciate your tolerance

THE *i*-MOS TEAM

- Principle Investigator: Prof. Mansun Chan
- Project Manager: Dr. Hao Wang
- Research Students:
  - Lining Zhang
  - Xiaoxu Cheng
- Collaborators:
  - Prof. Jin He, Peking University
  - Prof. Philip Wong, Stanford University
  - Prof. Yan Wang, Tsinghua University
  - Prof. Yu Cao, Arizona State University
- Funding: Hong Kong UGC AoE/P-04/08

THE BEGINNING

THANK YOU!