NEEDS:
Nano Engineered Electronic Device Simulation

Mark Lundstrom, Purdue
with
MIT, UC Berkeley, and Stanford
NCN and nanohub.org

“research and infrastructure network”
21\textsuperscript{st} Century electronics

“A new era of electronics that couples the power of billion-transistor CMOS technology with the new capabilities of emerging nano-devices.”

21\textsuperscript{st} Century electronics will:

- be less predictable
- be more differentiated
- address society’s grand challenges

Dennis Buss, “Microelectronics Industry in Transition,”
http://nanohub.org/resources/19576
materials and devices $\rightarrow$ circuits and systems

- analytical description
- compact models
- NEEDS

- device R&D
- theory / simulation
- experiment
- systems
- circuits

NEEDS
NEEDS Mission

**Mission:**
To provide SPICE-compatible and physics-based compact models for emerging nano-devices to researchers in industry and academia.

To create and deploy a complete **compact model development environment**, the associated **processes** and **educational resources**.

To help connect materials and device research to circuits and applications.
Nano-Engineered Electronic Device Simulation Node

NEEDS has a vision for a new era of electronics that couples the power of billion-transistor CMOS technology with the new capabilities of emerging nano-devices and a charter to create high-quality models and a complete development environment that enables a community of compact model developers.

NEW COMPACT MODEL RELEASE

MVS 1.0.1, MIT's Virtual Source model for Si nano transistors is now available. See Compact Models.
NEEDS compact models

MVS 1.0.1 Nanotransistor Model (Silicon)
By Shaloo Rakheja, Dimitri Antoniadis (MIT)

Abstract—
The MIT Virtual Source (MVS) model is a semi-empirical compact model for nanoscale transistors that accurately describes the physics of quasi-ballistic transistors with only a few physical parameters.

Model Release Components:

- MVS Model 1.0.1 in Verilog-A
- MVS Model Circuit Simulation Benchmarks
- MVS Model Exerciser in MATLAB
- MVS Model Parameter Extractor in MATLAB
- MVS Model Manual
- Experimental Data from Intel 32 nm and 45 nm N-type devices
- Details of changes in this version
- The model release components are licensed under a modified CMC license.

Licensing
compact models under development

- MVS model for Si nanotransistors (Antoniadis, MIT)
- MVS model for GaN FETs (Antoniadis and Palacios, MIT)
- MVS model for CNT FETs (Wong, Stanford)
- NEM resonator model (Daniel/Weinstein, MIT)
- FET-BASED Nano-biosensor models (Alam, Purdue)
- Spintronic device model (Datta, Purdue)
- Thermoelectric device model (Lundstrom, Purdue)
- Technology agnostic solar cell model (Alam and Lundstrom, Purdue)
- RRAM model (Wong, Stanford)
- CNFET model (Wong, Stanford)
- Phase change memory model (Stanford)
- BTBT FET model (Purdue, MIT)
- CBRAM model (Wong, Stanford)
- NEMS Relay model (Alon, Berkeley)
- Optical modulator (Daniel/Watts, MIT)
- VCSEL model (Chang-Hasnain, Berkeley)
- …
NEEDS compact models

1) Early stage models for assessing new technologies.

2) Version 1 models for design.
VS model for CNTFETs

Carbon Nanotube Computer

Max M. Shulaker, Gage Hills, Nishant Patil, Hai Wei, Hong-Yu Chen, H.-S. Philip Wong & Subhasish

FET-based models for bio-sensors (Alam group)

Ion Torrent (Nature, 475, 349, 21 2011)
circuit models for spintronic devices (Datta group)

Seamless integration of circuit components from diverse device models like NEGF, Spin diffusion
wireless networked medical electronics

- Glaucoma monitoring
- Seizure detection
- Prosthetic arm control
- Heart failure warning

Pedro Irazoqui
Biomedical Engineering
Purdue
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Berkeley compact model development platform

Verilog-A

Matlab
- Modspec Model (Matlab)
- MDE DC/AC/TRAN (Matlab)

C++
- Modspec Model (C++)
- MDE DC/AC/TRAN (C++)

Open-source
Commercial
SPICE
Berkeley compact model development platform

1) Enable early-stage circuit assessment of novel device concepts and Matlab-based workflows that result in high-quality Verilog-A models.

2) Facilitate the insertion of compact models open-source and commercial SPICE-compatible simulators.

Jaijeet Roychowdhury, UC Berkeley
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COMPACT MODELS
- SPICE-compatible Verilog-A format supporting resources

NEEDS MODEL DEVELOPMENT PLATFORM
- Environment for developing compact models

FOR DEVELOPERS
- Resources for using NEEDS models and for creating compact models with NEEDS tools and processes

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