

How to Fail Commercially in Material Modeling

Zlatan Stanojević

Global TCAD Solutions GmbH,
Böserndorferstraße 1/12,
1010 Vienna, Austria



27 February, 2019

How to Fail Commercially in Material Modeling as a Software-Owning Small or Medium Enterprise

Zlatan Stanojević

Global TCAD Solutions GmbH,
Böserndorferstraße 1/12,
1010 Vienna, Austria



27 February, 2019

1. Who we are & what we do
2. Dangers for SWO SMEs
3. Remarks on
 - TCAD as a service (TaaS)
 - Licensing
 - SW development
 - Funding

About Global TCAD Solutions

Who we are

- SME located in Vienna
- Founded 2008 as spin-off from the TU Wien
- Software owner (SWO)
- Supply SW to semiconductor industry & research
- Focus on advanced logic and memory

What we do

- Software development
- Product: GTS Framework
- Integrated toolset
- Intuitively interoperable
- In-house research
- Scientific publications
- Training (also as part of sales process)

What is TCAD? (Technology Computer Aided Design)

Device simulation

- Electrostatics
- Charge transport
- Quantum confinement
- Recombination
- Carrier heating
- Impact ionization
- Traps
- Predicts electrical characteristics from device structure and material properties

Process simulation

- Implantation
- Diffusion
- Annealing
- Etching
- Growth
- Deposition
- Oxidation
- Virtual fabrication of device structure

Simulation challenges in advanced logic and memory

- Quantum confinement
Transistor channel diameters of a few nm; wave-properties of electrons become apparent
- Breakdown of charge transport model
Transistor channel lengths 20-30 nm; near-equilibrium assumption of drift-diffusion eq. invalid; change of mechanism towards ballistic transport + scattering
- Variability
Transistor body very small; random-dopant fluctuations, structural variations, noise, ...
- Reliability
Transistor parameter drift/aging, defects/traps, time to failure prediction

TCAD in the context of Electronic Design Automation

Abstraction level	Transistors	Description	Quantity
System level	1.000.000.000	Behavioral	Message
Register transfer level (HDL)	1.000.000		
Gate level	1.000.000	Signal state	0/1
Transistor level (compact)	10.000	ODE	I
Classical TCAD (distributed)	100	PDE (DD)	$\mathbf{J}(x, y, z)$
Nano TCAD	1	PIDE (SBTE)	$\mathbf{J}_n(x, y, z, E)$
Quantum transport	≤ 1	NEGF	
Atomistic	< 1	DFT	

TCAD in the context of Electronic Design Automation

Abstraction level	Transistors	Description	Quantity
System level	1.000.000.000	Behavioral	Message
Register transfer level (HDL)	1.000.000		
Gate level	1.000.000	Signal state	0/1
Transistor level (compact)	10.000	ODE	I
Classical TCAD (distributed)	100	PDE (DD)	$\mathbf{J}(x, y, z)$
Nano TCAD	1	PIDE (SBTE)	$\mathbf{J}_n(x, y, z, E)$
Quantum transport	≤ 1	NEGF	
Atomistic	< 1	DFT	

DTCO

Design-Technology Co-Optimization

TCAD in the context of Electronic Design Automation

Abstraction level	Transistors	Description	Quantity
System level	1.000.000.000	Behavioral	Message
Register transfer level (HDL)	1.000.000		
Gate level	1.000.000	Signal state	0/1
Transistor level (compact)	10.000	ODE	I
Classical TCAD (distributed)	100	PDE (DD)	$\mathbf{J}(x, y, z)$
Nano TCAD	1	PIDE (SBTE)	$\mathbf{J}_n(x, y, z, E)$
Quantum transport	≤ 1	NEGF	
Atomistic	< 1	DFT	

Things that can kill an SWO SME

1. Marketplace
2. Organization
3. Technical debt

Killer No. 1: the marketplace

- High specialization of solutions fosters emergence of oligopolies and de-facto monopolies.
- Beating a monopoly is extremely difficult.
- Competing with status-quo solutions
- Competing with in-house solutions
- Customers will use the situation to their advantage.
- Customers sometimes do not realize the limitations of SMEs.
- “Can you do ... with your tool?”
- Feedback is scarce.
- Intelligence gathering is crucial.

Killer No. 2: organization

- Organic growth limits the number challenges that can be taken on.
- SMEs usually can't afford redundancies in personnel.
- Every field/product/project has one person assigned to it.
- Risk of deadlock
- Direct line with researchers & developers appreciated by customers but comes with a price
- Human factor

Killer No. 3: technical debt

- Trade off between implementation speed and quality
- Fast (and sloppy) implementations *borrow*s time from the future
- Technical debt must be repaid (with interest) at some point in time.
- Later changes to interfaces (API, UI, syntax) create difficulties with existing users.
- Modularity and software reuse
- Changing results
- Academic software comes with hidden technical debt
- On the other hand: risk of over-engineering

Feasibility of TCAD as a service (TaaS)

Our advances

- Development of gtsNet layer
- Distributed computing on grid and cloud
- Hybrid operation
- End-to-end encryption
- Free web-based simulation service (MyGTS)

Industry feedback

- Little interest in TaaS
- Very tight security (e.g. blocking of https)
- Concerns that data resides unencrypted on execution node
- Corporations favor long-term investment in cluster infrastructure over “renting” cloud-nodes
- Cost of industry license higher than cost of hardware

Our tools

- Proprietary license
- Parts of initial code base from TU Wien; proprietary license
- API of simulators exposed in SDK – well-received by customers (both industry & academia)
- Closed file format – could be opened in the future
- Opening of certain components for interoperability

3rd-party tools

- **Licensing scheme must be clearly stated!**
- Libraries and tools with permissive licenses (BSD, MIT, Apache, ...)
- Numerics/LinAlg libraries
- GPL is problematic
- Permissive evaluation needed for proprietary tools/libraries
- SW developed in joint research projects

Academic vs. commercial SW development

- Long-term academic projects with heterogeneous funding and many developers \leadsto hidden technical debt
- Focused library-based academic projects (tenured professor in charge) \leadsto stability, feature-completeness
- Software projects are always long-term
- Research SW: 3 to 4 major versions until maturity
- Companies are more efficient when it comes to the *mundane* aspects of SW development, e.g. testing, multi-platform support, user support.
- Contact with industry
- Deduction of business expenses from tax

Remarks on public funding

- Fund more SMEs!
- SMEs are job creators, exporters & taxpayers \rightsquigarrow public good
- Explicit funding of SW projects
- SMEs eligible for research funding
- Research funding as marketplace
- Interdisciplinary match-making