Introduction to ECE614: Computational Electronics

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Moore's Law: the driving force being "scaling"

The accelerating pace of change...

1. Industrial Revolution
2. Light-bulb
3. Moon landing
4. World Wide Web
5. Human genome sequenced

...and exponential growth in computing power...

Computer technology, shown here climbing dramatically by powers of 10, is now progressing more each hour than it did in its entire first 90 years.

COMPUTER RANKINGS
By calculations per second per $1,000

Analytical engine
Never fully built, Charles Babbage’s invention was designed to solve computational and logical problems.

Colossus
The electronic computer, with 1,500 vacuum tubes, helped the British crack German codes during WW II.

UNIVAC I
The first commercially marketed computer, used to tabulate the U.S. Census, occupied 943 cu. ft.

Apple II
At a price of $1,298, the compact machine was one of the first massively popular personal computers.

Power Mac G4
The first personal computer to deliver more than 1 billion floating-point operations per second.

...will lead to the Singularity

Surpasses brainpower of human by 2045

Surpasses brainpower of human in 2023

Surpasses brainpower of mouse in 2015
Current trends in the IC/transistor industry

• Reducing “size” (typically means gate length) improves performance
Technology Innovation

• The actual device structure is evolving towards “nano”
Novel technology options are being explored in the pipeline to ensure the continuance of Moore's law.
Elements of Device Simulation

- All the different approaches we will discuss are part of the “transport”
How do we measure length scales?

- What makes a device “small”—what is the relevant “yardstick”?

<table>
<thead>
<tr>
<th>Transport Regime</th>
<th>$L &lt;&lt; l_{e-ph}$</th>
<th>$L \sim l_{e-ph}$</th>
<th>$L &gt;&gt; l_{e-ph}$</th>
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<tbody>
<tr>
<td>$L &lt; \lambda$</td>
<td>Quantum</td>
<td>Fluid</td>
<td>Diffusive</td>
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<tr>
<td>$L &lt; l_{e-e}$</td>
<td>Ballistic</td>
<td>Fluid</td>
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<tr>
<td>$L &gt;&gt; l_{e-e}$</td>
<td>Fluid</td>
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<thead>
<tr>
<th>Scattering</th>
<th>Rare</th>
<th>Rare</th>
<th>e-e (Many), e-ph (Few)</th>
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<tbody>
<tr>
<td>Model:</td>
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<td>Drift-Diffusion</td>
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<td>Hydrodynamic</td>
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<td>Monte Carlo</td>
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<td>Schrodinger/Green's Functions</td>
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<td>Applications</td>
<td>Nanowires, Superlattices</td>
<td>Ballistic Transistor</td>
<td>Current IC's</td>
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Relationship between various transport regimes and significant length-scales.
Assignments

• Read Chapter 1: Introduction (section 1.2 is optional)
• Next week: we will cover Bandstructure and Density of States in detail
• Review Chapters 2.1 and 2.2 on Crystal Structure and Semiconductors
• (Optional, but strongly recommended) Read 2.9 review of semiconductor devices