What are keys to this success that you can apply as well?

Is the answer solving problems & refining solutions?
Scientific Method!

Pick Problem

Insight & 1st Hypotheses

Test/Refine Hypotheses

Repeat steps as needed

16 October 1964, Volume 146, Number 3642

Strong Inference
Certain systematic methods of scientific thinking may produce much more rapid progress than others.

John R. Platt
Outline

Pick Problem

Insight & 1st Hypotheses (longer)

Academic Research → Industrial Pathfinding

Spoiler:
More Similar Than Different
Seek Problems First – Don’t Play Jeopardy

If you can do it, people will care.

You can do (some of) it.

Look for Changes

• Technology
• Computer Use
• Other (sub-)fields

A Case for Redundant Arrays of Inexpensive Disks (RAID)

David A. Patterson, Garth Gibson, and Randy H. Katz

Thomas Watson, Sr., 1911: THINK
Outline

Pick Problem

Insight & 1st Hypotheses (longer)
• Taxonomies
• New perspectives
• Models
• Collaborate

Academic Research → Industrial Pathfinding
Insight: **Taxonomy** → **3C Cache Misses**

1980s: Fascinated by caches & virtual memory
• Create illusion better than the technology
• But there was/is a data deluge

Richard Hamming: *The purpose of computing is insight, not numbers.*
Insight: Taxonomy $\rightarrow$ 3C Cache Misses

Conflict
Capacity
Compulsory

Jouppi stream buffers
Into Undergrad
Canon [H&P COD]

1988 PhD w/ David A. Patterson & Alan Jay Smith
Insight: **Taxonomy**: Long History in Science

Mendeleev’s Periodic Table, 1869
“The mother of scientific taxonomies”
Insight: New Perspectives → Data Race Free Memory Consistency

1990s: Shared-memory multiprocessors “here” (wrong: niche for another decade)
• Coherence → caches invisible

Whither correctness?
• Lamport defined Sequential Consistency
• Real machines violated SC w/ write buffers, out-of-order, non-atomic stores, etc.

Albert Einstein: *Everything should be made as simple as possible, but not simpler.*
Insight: New Perspectives → Data Race Free Memory Consistency

@ Talk by Bart Miller SW data race detection → Connection between data races & relaxed models → Sequential Consistency for Data-Race-Free programs

Weak Ordering - A New Definition†

Sarita V. Adve
Mark D. Hill

Release Consistency
in same 1990 session

The Java Memory Model

Jeremy Manson and William Pugh
Sarita V. Adve

Foundations of the C++ Concurrency Memory Model

Hans-J. Boehm
Sarita V. Adve

Heterogeneous-race-free Memory Models

Derek R. Hower†, Blake A. Hechtman†§, Bradford M. Beckmann†, Benedict R. Gaster†, Mark D. Hill†, Steven K. Reinhardt†, David A. Wood†

Also for Rust coming soon
Insight: **Models → Gables & Accelerator-level Parallelism**

2010s: Systems on Chip (SoCs) grow up
- CPUs, GPUs, many accelerators, interconnects, coherence, virtual memory, virtualization, etc.

2018 Google intern charge:
- “Make SoC design more scientific”
- 1st reaction: Gasp!

Do a simple model: Gables [HPCA 2016]
Accelerator-level Parallelism [CACM 2020]

Also **Collaborate**: 3 sabbaticals in industry (Sun ‘95, AMD ‘11, Google ‘18) + ~25 industrial affiliate meetings
Collaborate for Ideas & Connections: 160 Co-Authors in 2019
Outline

Pick Problem

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• Taxonomies
• New perspectives
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Academic Research → Industrial Pathfinding
Computer Architects: Components \(\rightarrow\) Systems

Since December 2020: Hardware-software pathfinding for Azure
Research AND Pathfinding: Heilmeier Catechism

1. What are you trying to do? Articulate your objectives using absolutely no jargon.
2. How is it done today, and what are the limits of current practice?
3. What is new in your approach and why do you think it will be successful?
4. Who cares? If you are successful, what difference will it make?
5. What are the risks?
6. How much will it cost?
7. How long will it take?
8. What are the mid-term and final “exams” to check for success?

(Academic) Research → Industrial Pathfinding

<table>
<thead>
<tr>
<th>(Academic) Research</th>
<th>Industrial Pathfinding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correctly predict inflection points</td>
<td>Correctly predict inflection points &amp; TIMING</td>
</tr>
</tbody>
</table>

For Impact How Avoid?
- Just local optimizations
- “Boiling the ocean”

Future Back:
- E.g., from Microsoft class: medical wearables
  1. Consider “North Star” further out
  2. Work back to “incremental” next steps
P. S. Give Forward – Teaching & Service

UW teaching 32 years & Dept. Chair
ACM Sigarch Berenbaum Service Award
Computer Community Consortium
Outline

Pick Problem

Insight & 1st Hypotheses (longer)
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Academic Research → Industrial Pathfinding

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More Similar Than Different