DOMAINS, DUALITIES
AND
THEORETICAL
COMPUTER SCIENCE

Michael Mislove
Pendergraft Investiture
May 5, 2008
COMPUTER SCIENCE
• Two views:
COMPUTER SCIENCE

• Two views:
  
  • *Engineering discipline*: Build faster machines, more robust networks,...
COMPUTER SCIENCE

• Two views:
  • *Engineering discipline*: Build faster machines, more robust networks,...
  • *Scientific discipline*: 
Two views:

- Engineering discipline: Build faster machines, more robust networks,...
- Scientific discipline:
  - Faster, more complex algorithms
COMPUTER SCIENCE

• Two views:
  • Engineering discipline: Build faster machines, more robust networks, ...
  • Scientific discipline:
    • Faster, more complex algorithms
    • What is computable? What is the theory of computation? Science in Computer Science
EARLY COMPUTERS

- 1940s - 1980s: The computer as gigantic calculator
  - Mainframe: input - output device
EARLY COMPUTERS

• 1940s - 1980s: The computer as gigantic calculator
  • Mainframe: input - output device

• But: computer programs are *complicated!*
DUALITY
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- Having two aspects / complementary facets
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  • Dualism of mind and body - Descartes
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  • Wave / particle duality of light - Huygens vs. Newton
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• Mathematics: A theory presenting two equivalent ways of looking at the same thing.
DUALITY

- Having two aspects / complementary facets
  - Dualism of mind and body - Descartes
  - Wave / particle duality of light - Huygens vs. Newton
- Mathematics: A theory presenting two equivalent ways of looking at the same thing.

One of the principle objects of theoretical research in any department of knowledge is to find the point of view from which the subject appears in its greatest simplicity.

J. W. Gibbs
ANALYZING PROGRAMS
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Computer Program
While x < 0 do
  y := x - 5
  x := y - 3
ANALYZING PROGRAMS

Domains model programs as functions

Computer Program
While x < 0 do
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ANALYZING PROGRAMS

Computer Program
While $x < 0$ do
  $y := x - 5$
  $x := y - 3$

Domains model programs as functions

Logical theory
Inference rules for reasoning about Computer Program
ANALYZING PROGRAMS

Computer Program
While \( x < 0 \) do
  \( y := x - 5 \)
  \( x := y - 3 \)

Domains model programs as functions

Logical theory as Mathematical model
ANALYZING PROGRAMS

Computer Program
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Domains model programs as functions

Logical theory as Mathematical model

Duality
ANALYZING PROGRAMS

Computer Program
While $x < 0$ do
  $y := x - 5$
  $x := y - 3$

Domains model programs as functions

Duality

HMS

Logical theory as Mathematical model
DISTRIBUTED COMPUTING

- Systems of networked computers
- Exponential increase in complexity
- Probabilistic models
DISTRIBUTED COMPUTING

- Systems of networked computers
- Exponential increase in complexity
- Probabilistic models

Concurrent processes

Markov Processes

MPW Duality

Logic as Testing theory
THE INTERNET
THE INTERNET

- We have moved beyond using computers to calculate
THE INTERNET

- We have moved beyond using computers to calculate
  - Now use them to communicate, collaborate
THE INTERNET

- We have moved beyond using computers to calculate
  - Now use them to communicate, collaborate
  - Computers are now *interactive*
THE INTERNET

• We have moved beyond using computers to calculate
  • Now use them to communicate, collaborate
  • Computers are now *interactive*
  • What *is* the mathematics needed to model this?
THE INTERNET

• We have moved beyond using computers to calculate
  • Now use them to communicate, collaborate
  • Computers are now *interactive*
• What *is* the mathematics needed to model this?
  • No single locus of control
A MATURING SCIENCE
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• Computer science is reaching out to apply its tools to:
A MATURING SCIENCE

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  - Physics, quantum and classical information, geometry
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  • Clifford Lectures, Tulane, March, 2008
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    • Using process algebra to give *qualitative model* for membranes, proteins
A MATURING SCIENCE

- Computer science is reaching out to apply its tools to:
  - Physics, quantum and classical information, geometry
    - Clifford Lectures, Tulane, March, 2008
  - Systems biology
    - Using process algebra to give qualitative model for membranes, proteins
  - Jeannette Wing (NSF): Large areas of science are comprised of computational processes
THE BRAVE NEW WORD
"Yeah, I know it's a little hard to hear me, I'm on my cell phone!"
MENTORS,
STUDENTS, POSTDOCS
MENTORS, STUDENTS, POSTDOCS
CAROLINE, MARILYN & ALAN