Interdisciplinary research at Bell Labs

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Outline

Three projects

1994-1998       WISE: wireless system engineering
1998-2003       Ocelot: cellular system optimization
2001-present   Frog: optical network simulation

Value

Success indicators

Challenges

Caveats:

- industrial research
- `modelling + algorithms + database + gui`
- computer science viewpoint
WISE: wireless system engineering

Initial problem:
in-building wireless system design

Eventual functionality:
predict propagation in complex environments
optimize antenna locations

Methods:
CS: ray-tracing, computational geometry,
derivative-free optimization,
GUI, software engineering
Radio: propagation modeling

Innovations:
Algorithms, modeling, measurements

Steven Fortune, Margaret Wright, Brian Kernighan,
Reinaldo Valenzuela, Dmitry Chizhik, Jon Ling,
Vinco Erceg, ....
Ocelot: Cellular optimization tool

**Coverage Improvement With Ocelot**

**Initial problem:**
reduce drive tests for installation of cellular systems

**Eventual functionality:**
predict coverage-capacity tradeoff
optimize power, antenna direction, pilot

**Expertise:**
nonlinear optimization, stochastic modeling, geometric algorithms, software engineering

**Innovations:**
comprehensive, differentiable, analytic models of cellular systems

Ken Clarkson, John Hobby, John Graybeal, Howard Trickey, Paul Polakos, Alvaro Diaz, Chandra Chekuri, Lisa Zhang, David Abrusch-Magder, Larry Drabeck, Georg Hampel, Jay Srinivansan, …
FROG: physical-level WDM optics simulation

Initial problem:
Design optical amplifier control algorithms

Eventual functionality:
both steady-state and dynamic simulation of amplifier power levels

Expertise:
CS: PDEs, discretization, software
Optical: Raman, Rayleigh back-scattering, fiber propagation, …

Innovations:
Multiscale (µs-ks, m-Mm), huge state space
Simulation of both physics and control alg

Tin Ho, Todd Salomon, Wonsuck Lee, Bruce Hillyer, Chris White, Lawrence Cowsar, Roland Freund, Dan Kilper, …
Value

Wise

Technical: state-of-the-art in 1995, still seems to be state-of-the-art
Simulations, e.g. MIMO
Business: market evolved unexpectedly; blueprint acquisition

Ocelot

~90 RF engineers, ~10 support staff; middle swath of China
CTIA roll-out in 2001: established Lucent credibility in CDMA

FROG

risk mitigation: laboratory simulation of $100M networks
Lucent credibility in ultra-long-haul optical networks
Computer Science Essential

**Wise**
at least x1000 improvement in algorithms
geometric algorithm implementation
effective derivative-free optimization

**Ocelot**
forget simulated annealing:
  - project driven by need for continuous, differentiable objective function
  - probability, queuing theory, statistics, geometric algorithms, …

**FROG**
choice of PDE solver
  - adaptive grids, multiscale event simulation

*software: architecture, databases, GUI, feature management*
Success indicators

Clear problem statement

- mini "Grand Challenge"
- team: goal-oriented, not discipline oriented

Address cultural pitfalls

- learn each other's language
- expectations: contributions, paper authorship, ...
- respect: CS is much more than coding

Project organization

- Project 'angel'

Start small; get to demo quickly

- communicate; build support; discover deeper models and issues
Evaluation and rewards

Computer science, even sophisticated computer science, is essential, but the results (in these cases) are primarily not computer science

- Dozens of publications, most not in CS journals
- Perception: individual PI reputation in CS degraded, not enhanced

Who evaluates? Who gets the credit? How is work rewarded?

Bell Labs:

- Long tradition of evaluating and respecting interdisciplinary work
- Plenty of reward mechanisms
  - (4 DMTS, 2 BL Fellows, 3 DH, 1 VP; internal awards; raises, bonuses, etc.)
Promoting university interdisciplinary work

Culture change
  medieval guild model
  tenure promotes specialization
    interdisciplinary work requires breadth

Motivational arguments
  broader impact
  exciting
  new, well-motivated, real problems within discipline
  funding agencies like new directions

Actions
  curriculum: "algorithms in the real world"
  outlets in prestigious journals
  CS chairs: pre-tenure: discourage; post-tenure: encourage
  Deans: break down barriers, interdisciplinary centers, ...