# DISRUPTIVE INNOVATIONS

**Barry L. Shoop, Ph.D., P.E.**
**Professor and Head**
**Department of Electrical Engineering and Computer Science**
**United States Military Academy**
**West Point, New York**

Cape Town, South Africa

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# Outline

- Background and Motivation
- Overview of XE492 Disruptive Innovations course
- Disruptive innovations – background, definitions and examples
- The importance of the human dimension in technology development
- Examples of disruptive innovations
- Summary and observations

# Expectation Management

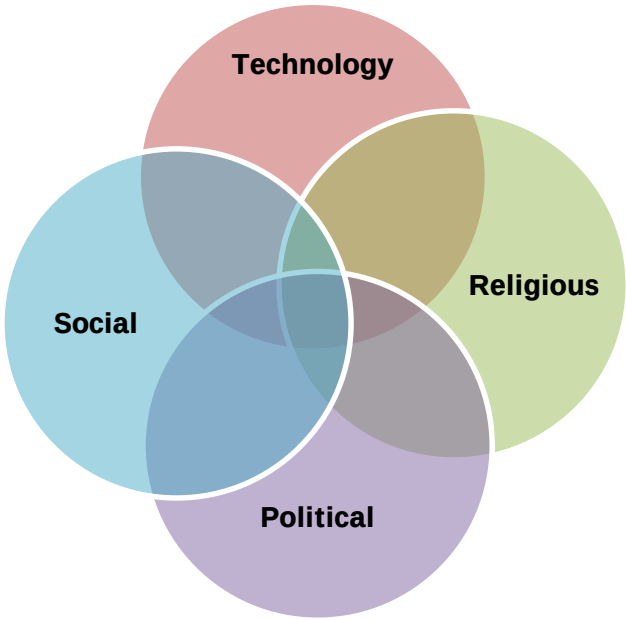


- Introduce the concept of disruptive commercial technology and innovation and the implications to commercial, for-profit companies
- Not intended to be a lecture but instead a dialog
- Desired outcome is for you to think more broadly about the all of the dimensions of innovation – including technology – social – political – religious
- Rest assured – I don't have all the answers! My goal is to stimulate broader thinking about innovation and the organizational and cultural aspects that encourage it

# Disruption & Innovation

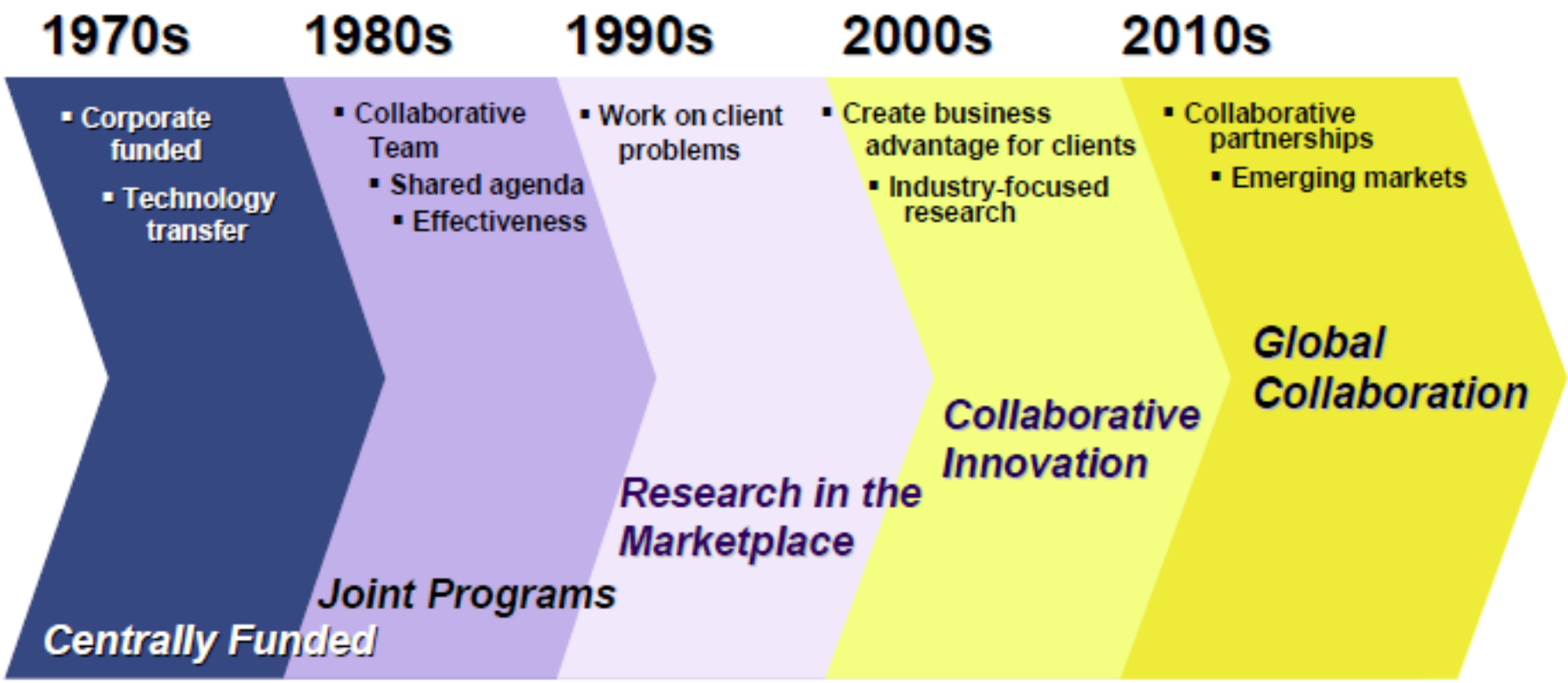


- **Context of Innovation is Much Broader than Technology.**
  - "Innovation" is currently oversubscribed.
    - Many, many, many articles and books in the literature.
    - Most consider from a pure technology or business perspective.
  - Technology is clearly at the core.
  - Business practices are important.
  - Human dimension is critical for adoption.
    - Social, political, and religious influences.
  - History is replete with examples of innovations that were not adopted because of social and religious influences.



# Evolution of Innovation





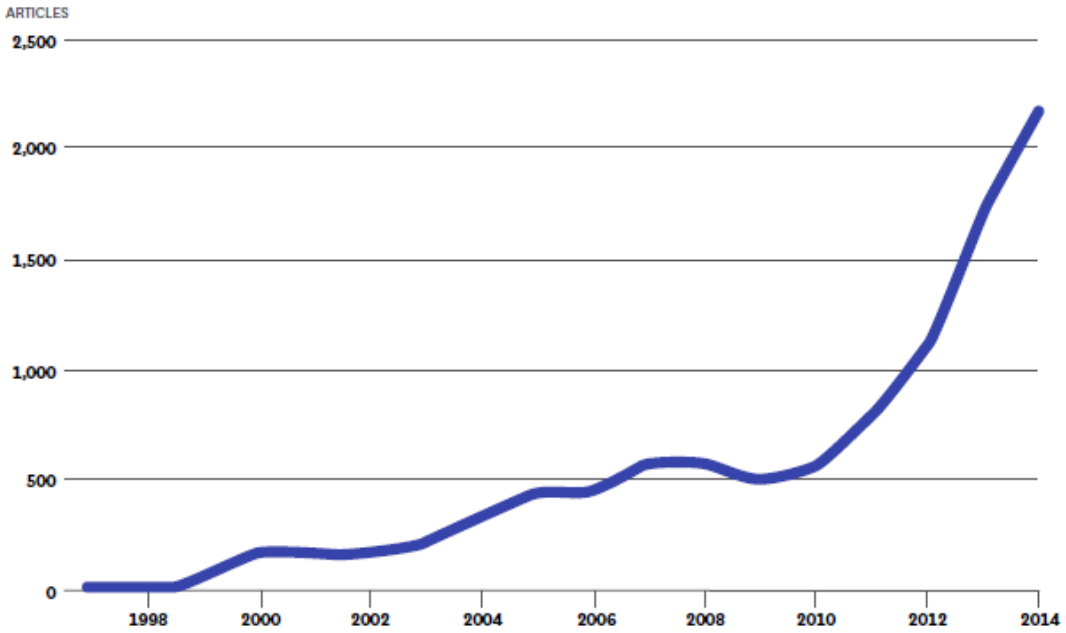

***Inter-disciplinary collaboration in the market and across the globe***

# Disruptive Innovation

*Department of Electrical Engineering and Computer Science*

**THE UBIQUITOUS "DISRUPTIVE INNOVATION"**

"Disruptive innovation" and "disruptive technology" are now part of the popular business lexicon, as suggested by the dramatic growth in the number of articles using those phrases in recent years.




SOURCE FACTIVA ANALYSIS OF A WIDE VARIETY OF ENGLISH-LANGUAGE PUBLICATIONS

The rate of disruption is accelerating and established industry leaders are failing and disappearing faster than ever. The average lifespan of a Fortune 500 company is in rapid decline:

- 61 years in 1958
- 25 years in 1980
- 18 years in 2011.

Some predictions call for it to drop to 6 years by 2020.

## Socratic Dialog

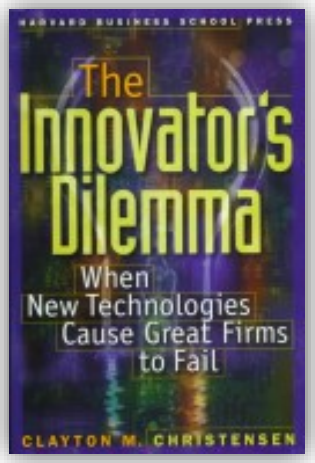
- A dialectic method of inquiry that uses cross-examination of an individual's claims in order to reveal contradictions or internal inconsistencies.
- Socratic questioning is at the heart of critical thinking.
- Challenges accuracy and completeness of thinking and deepens individual insights and understanding.
- Strengthens the student's skills at formulating a logical argument and their ability to effectively engage in a rational, oral debate.

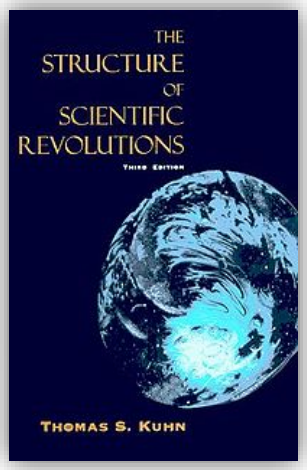
## The Thayer Method

- Thayer's educational philosophy demanded that every cadet be responsible for his own learning.
- Small class size, self-study and daily recitation are mutually supportive of the Socratic method.

## Upper-Division Interdisciplinary Course – XE492

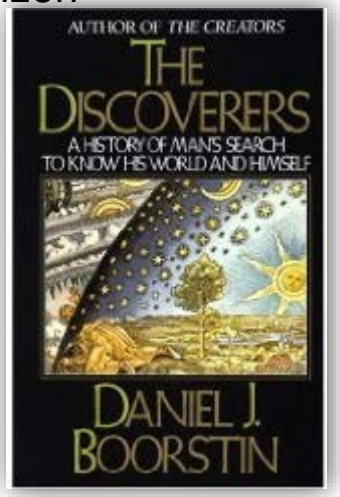
- Encourages disciplinary diversity

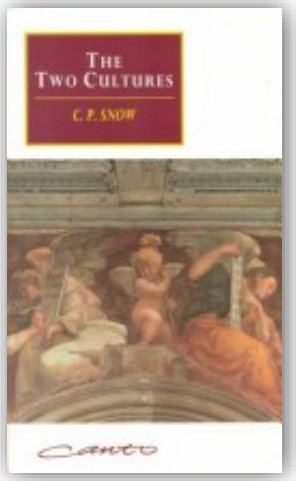



## Course Construct

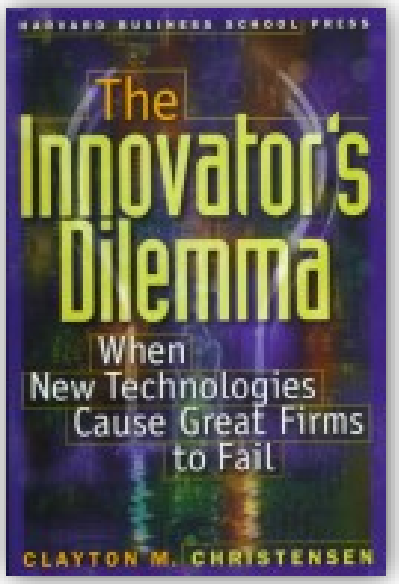
- Four course texts
  - *The Innovator's Dilemma*, Clayton M. Christensen
  - *The Structure of Scientific Revolutions*, Thomas S. Kuhn
  - *The Discoverers*, Daniel J. Boorstin
  - *The Two Cultures*, C. P. Snow
- Continuous survey of commercial technology horizon
- Class meetings focused on
  - Discussion of text readings
  - Discussion of commercial technologies
- Interviews with forward thinking technologists

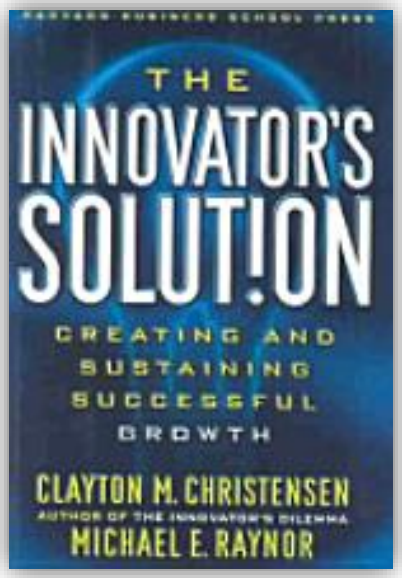


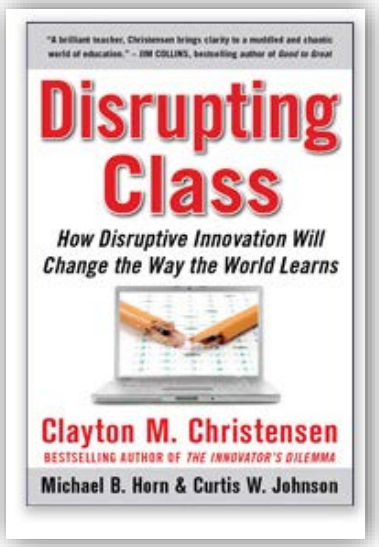



## THE INNOVATOR'S DILEMMA

- Clayton M. Christensen – Harvard Business School
- 1995 Article "Disrupting Technologies: Catching the Wave"
- Introduced the term "disruptive technology"
  - Innovations that improve a product or service in ways that the market does not expect, typically by being lower priced or designed for a different set of consumers

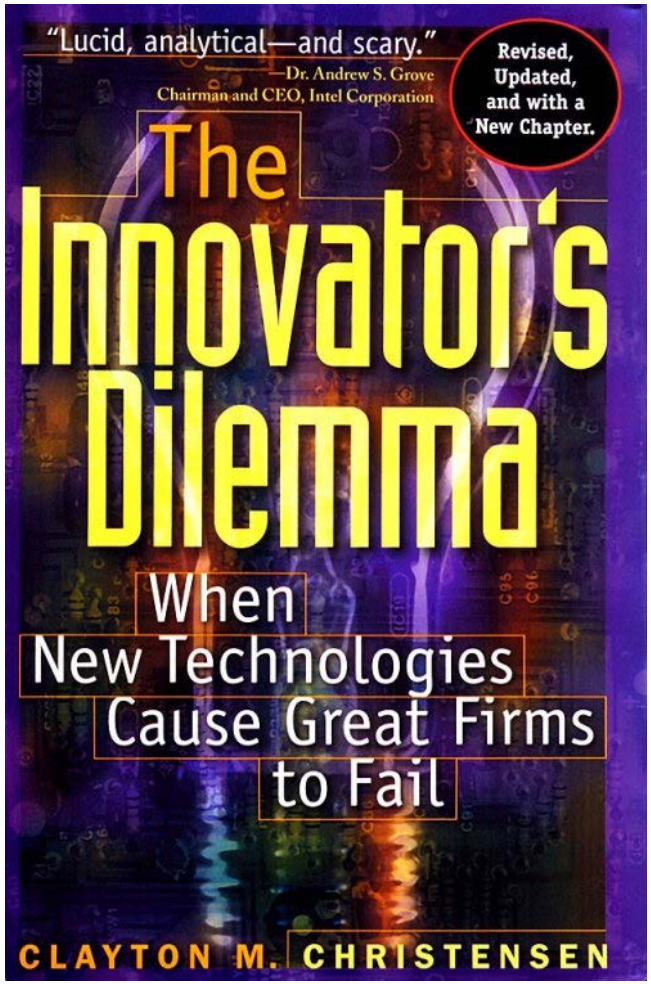



# The Innovator's Dilemma






# The Dilemma



- "One of the most consistent patterns in business is the failure of leading companies to stay at the top of their industries when technologies or markets change."

- "Why is it that companies like these invest aggressively – and successfully – in the technologies necessary to retain their current customers but then fail to make certain other technological investments that customers of the future will demand? Undoubtedly, bureaucracy, arrogance, tired executive blood, poor planning, and short-term investment horizons have all played a role. But a more fundamental reason lies at the heart of the paradox: leading companies succumb to one of the most popular, and valuable, management dogmas. They stay close to their customers."

"If I had asked people what they wanted, they would have said faster horses."
Henry Ford

# Definitions



**Sustaining technologies** – tend to maintain a rate of improvement; that is, they give customers something more or better in the attributes they already value.

**Disruptive technologies** – introduce a very different value proposition, generally underperform established products in mainstream markets, but have other features that niche market customers value. They are typically cheaper, simpler, smaller, and frequently more convenient to use.

| | | |
|---|---|---|
| High-Density Disk Drives | → | Portable Disk Drives |
| Digital Photography | → | Traditional Photography |
| Catalog Retailing | → | Clothing Sales Stores |
| Midwives | → | Maternity Doctors |
| Distance Learning | → | Traditional Campus-Based Education |
| Digital Textbooks | → | Traditional Hardcopy Textbooks |

# Disruptive Innovations



1. Initially underperforms the dominant one along the dimensions mainstream customers in major markets have historically valued.
2. Has other features a few fringe (and generally new) customers value. Products based on disruptive technologies are typically (1) cheaper, (2) simpler, (3) smaller, or (4) more convenient than those established on the dominant technology.
3. Profitable customers generally do not want and initially cannot use products based on disruptive technologies. So disruptive technologies are first commercialized in emerging or niche markets. Incumbents conclude that investing in disruptive technologies is not a rational financial decision for them.
4. The new disruptive technology steadily improves in performance until it meets the standards of performance demanded by the mainstream market.
5. At that point, the disruptive technology displaces the dominant one and the new entrant displaces the dominant incumbent(s) in the mainstream market.

# Organizational Structure



Dedicated Entity

Incubator

Accelerator

Cross-functional collaboration

*Scrum – Agile Software Development*

*Delegation of Decisions to Innovation Teams*

*Integration of R&D into the Business Units*

*Co-Location of Teams and Departments*

*Central Innovation Teams*

*Central Innovation Funds*

*External Interface for Open Innovation*

*Merger & Acquisition Department*

- Bell Labs: deliberately laid-out to promote unexpected interactions. The corridors were long and designed to promote random meetings.
- MIT Building 20: horizontal layout spurred interactions amongst widely diverse disciplines;
- Pixar - building arranged around a central atrium, so that Pixar's diverse staff of artists, writers, and computer scientists would run into each other more often

*Innovative Organizational Structures Facilitate Collaboration*

# Organizational Culture



**An Environment of Trust** – Reciprocal Trust. There is risk involved in innovation. Highly creative ideas often initially sound stupid.

**Empower People** – people are given ownership and the ability to act

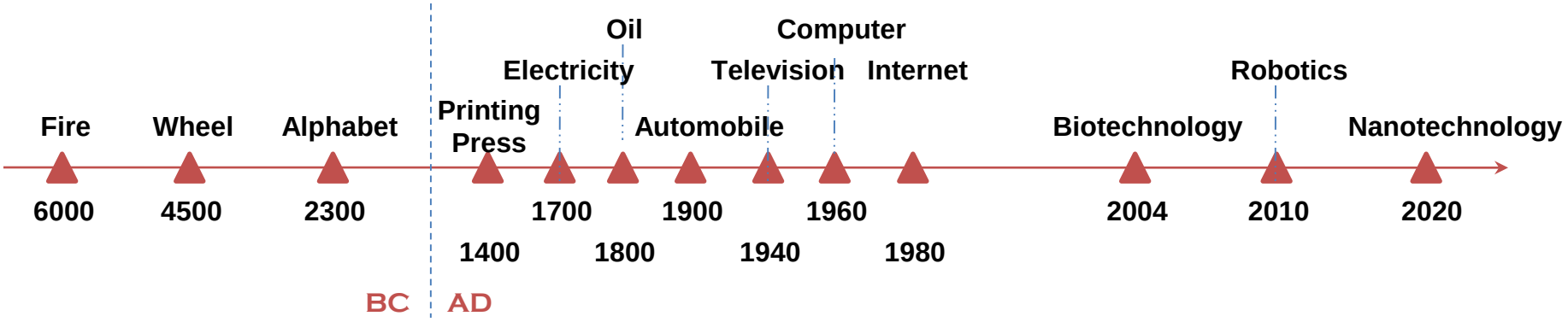
**Argue Passionately** – argue about ideas and concepts, but don't make it personal.

**Innovation is a Team Sport** – One key aspect of a culture that nurtures innovation is collaboration: across departments and teams, and up and down the organization – and this collaboration flows from trust.

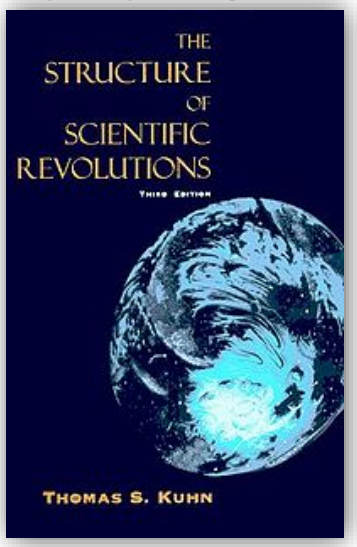
*Apple uses the entire company as a new-idea generator; Google encourages employees to spend 20% of their time working on their own ideas; 3M sets the goal of earning 30% of its revenues from products introduced in the past five years.*

*Identifying Problems – sales and support teams engage customers on a daily basis and have tremendous insights for developers on user needs*

## Disruptive Technologies that Fundamentally Changed the Planet



# The Structure of Scientific Revolutions

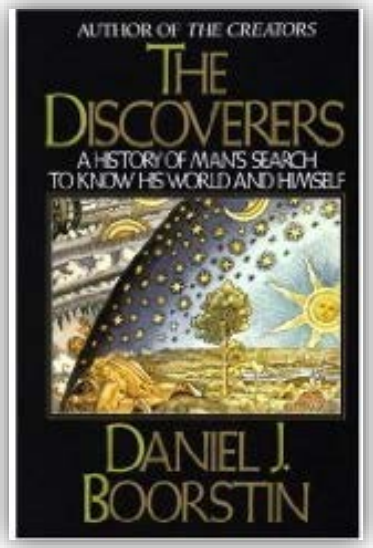



- Thomas S. Kuhn – U.C. Berkeley – Philosophy & History
- Science does not progress in a linear accumulation of knowledge but undergoes periodic revolutions – paradigm shifts
  - Prescience – lacks a central paradigm
  - Normal science – puzzle-solving – failure of results to conform – crisis
  - Revolutionary science
- Small and large scientific revolutions
- Introduces the concept that scientific knowledge is dependent on the culture and historical circumstances of groups of scientists rather than on their adherence to a specific, definable method
- Depicts science as a human process – mistake-prone, competitive, argumentative, with personalities and propensities of the researchers themselves playing a significant role in the rate, if not the end results, of progress

*The Structure of Scientific Revolutions* probably represents some the best thinking on how transformation occurs, who drives it, why it is resisted, and what it really asks of people.

## The Discoverers

- Daniel J. Boorstin – American historian, professor, attorney, and writer. He was appointed twelfth Librarian of the United States Congress from 1975 until 1987
- The history of human discovery
  - Chronicles several inventions – the clock, the compass, the telescope and microscope, the printing press and movable type
  - Why didn't the Chinese "discover" Europe or America?
- Traces inventions and their acceptance or rejection based on culture, society, religion

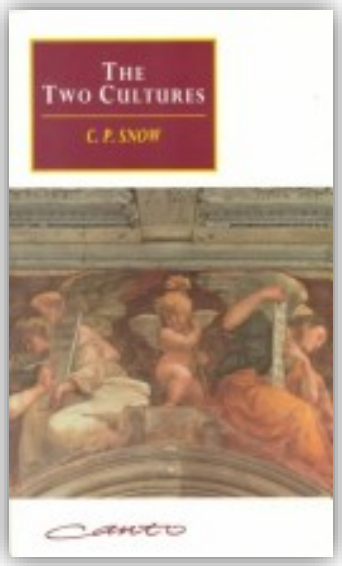



During the period when Prince Henry the Navigator was just beginning to explore the West coast of Africa, the Chinese had already built massive flotillas consisting of as many as 317 ships and had advanced the state-of-the-art of shipbuilding well beyond that elsewhere in the world. Bulkheads which divided the ship's hold into compartments to prevent flooding and fires and were first integrated by the Chinese are believed to have been inspired by the septa, the transverse membranes in bamboo.

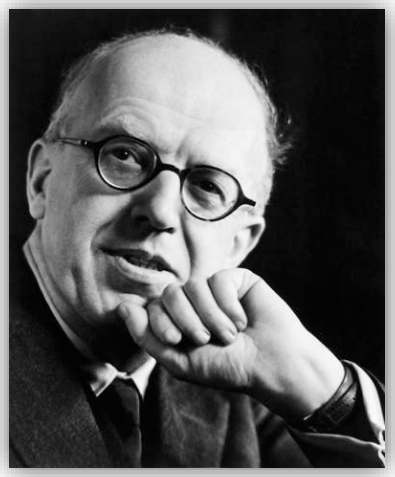
"The Chinese had long since developed their own version of the *oikoumeme*, the habitable world, which put them at the center. They were their own Jerusalem. Since the Ming emperors were the Sons of Heaven, they were by definition supreme rulers and superiors of all other people on earth."

While the Chinese developed the technological innovations necessary to position them as a seafaring nation, capable of exploration and expansion, their culture and beliefs prevented adoption and further development.

## The Two Cultures




- Charles Percy Snow – C. P. Snow - an English physicist and novelist
- 1956 article
  - "The Two Cultures"
- 1959 Cambridge University Rede Lecture
  - "The Two Cultures and the Scientific Revolution"
- Claim about academic disciplines
  - Split between the arts and humanities and the sciences
  - Questions educational structure, social attitudes, and government policy-making



"the intellectual life of the whole of western society is increasingly being split into two polar groups, ... "Literary intellectuals at one pole – at the other scientists. Between the two a gulf of mutual incomprehension – sometimes (particularly among the young) hostility and dislike, but most of all lack of understanding"

Snow argues that practitioners from the sciences and the humanities should build bridges to further the progress of human knowledge and to benefit society.

# Examples

## Movable Type Printing Press

- Johannes Gutenberg in 1440
- Revolutionized creation and distribution of information
- Expanded existing technology to create *movable* type printing
- Used existing technology – wine press technology used to print

## Linux Operating System

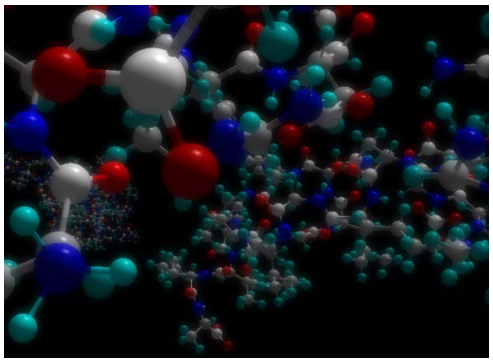
- When introduced was inferior in performance (underperformed) to other server operating systems like Unix and Windows NT
- New performance measure: Inexpensive and Open Source
- Linux now installed in 87.8% of the world's 500 fastest supercomputers


## Netflix

- Business model in 1998 was DVD-by-mail rentals – 2007 switched to streaming, on-demand
- Initial service not appealing to Blockbuster customers who wanted instant gratification when choosing movies
- Blockbuster bankrupt in 2010


*It's not just about the invention – but adoption … and the 2nd- and 3rd-order effects.*
*The automobile was important, not because it ended travel by horse*
*but because it created suburbs, gas stations and shopping malls*

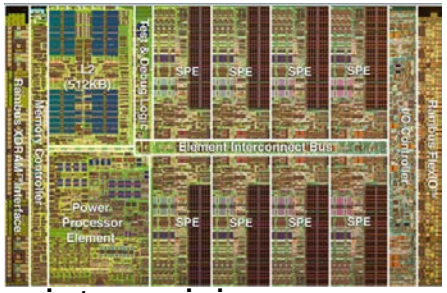
## Distributed Computing



- Fastest Virtual Supercomputers
  - BOINC – 1.3 PFLOPS as of February 9, 2009
  - Folding@Home – 8.7 PFLOPS, as of March 24, 2009

## Cluster Computing

- Fastest Commercial Supercomputer
  - Los Alamos National Lab's "Roadrunner" – 1.0 PFLOP
- PS3 cluster
  - Single-chip multiprocessor
  - 9 processors
    - 1 PowerPC
    - 8 vector processors
    - 1328.4 GFLOPS single point precision;
      97.2 GFLOPS double point precision





## GPU Computing

- Graphical Processing Unit
- Tesla – 240 cores
- Fermi – 512 cores

## Potential to Greatly Help Society

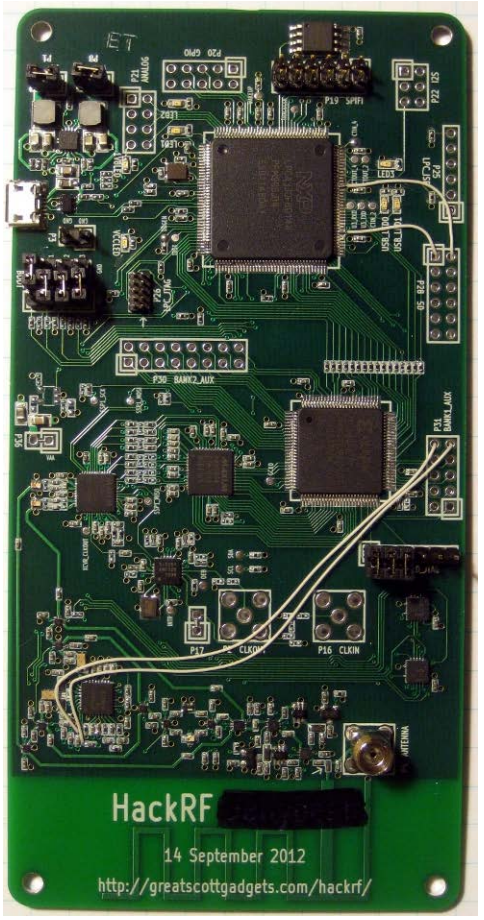
- Inter-agency communication during disasters
- Multi-protocol translation
- Cross-frequency communication


## Collaboration

- Freely accessible means more eyes on development
- Diversity breeds innovation
- “Crowd sourced” patches and add-ons

## HackRF by Great Scott Gadgets

- Open project [both hardware and software]
- SDR implementation for $300 + Laptop and Antenna
- Free to modify




**USB-powered software radio transceiver peripheral; operates from 30 MHz to 6 GHz.**

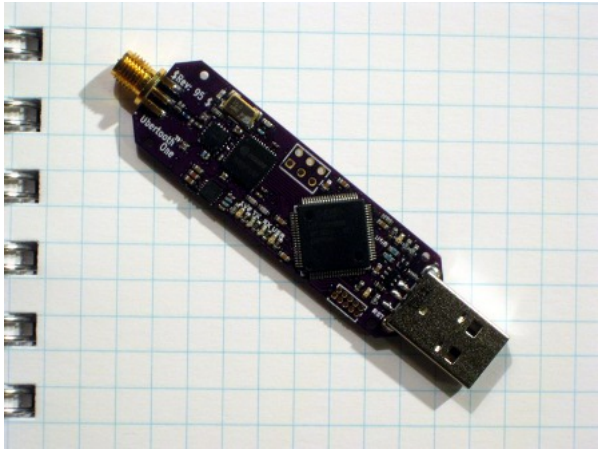
HackRF Jawbreaker. http://4.bp.blogspot.com/-wQg9OMTczhs/UGnB__INmcI/AAAAAAAAAg0/2F6DuzyW-IQ/s1600/jawbreaker.jpeg

## Potentially Dark Side as Well

- Monitoring
- Injection
- Encryption

## Niche Market

- Hackers
- Criminal Elements
- Military
- Emergency Personnel



Ubertooth One: open source 2.4 GHz wireless development platform suitable for Bluetooth experimentation

Accessibility:

criminal networks → insurgent groups →potential terrorists


RF spectrum analyzer with LEDs representing 13 evenly spaced Wi-Fi channels in the 2.4 GHz band

# Israel As a Start-Up Nation



## START-UP NATION

- Israel, a 60-year-old nation with a population of 7.1 million, was able to reach such economic growth that "at the start of 2009, some 63 Israeli companies were listed on the NASDAQ, more than those of any other foreign country"


## WAZE

- World's largest community-based traffic and navigation app.
- Recently purchased by Google for $1.3B

## WATERGEN

- Water vapor in the air is turned into potable drinking water

## ROBOTEAM

- Robotics platforms built from the ground up with the end user and application in mind

# Other Examples



## INTUIT

- Most software companies target corporate customers … $$$
- Intuit created business software for the masses
- 1983 – *Quicken* and *TurboTax* then *QuickBooks* for the needs of small business
- Key was to watch customers use the product rather than listening to what they or experts said they need

### QuickBooks

- Originally designed by accountants, CPAs and economists – *performance oversupply*
- Small business owners wanted adequate, not superior, functionality that was simple and convenient

## KAREO

- Cloud-based software for doctors in private practice to compete with large operations

## IPHONE

- June 2007 Steve Jobs & Apple launched iPhone – a hit
- ~1M sold in 1st year; after only 5-quarters surpassed Blackberry, the market leader

# Open Source

## Linux

- Open source operating system
- Based on Unix

## Advantages:

- No Cost
- Maximize use of hardware and software

## Use Linux to:

- Create new applications
- To edit existing applications

Linus Torvalds

# Disruption and Ecosystems

## Intuit - QuickBooks

- Apps.com – an ecosystem for small businesses
- Provide tools so developers can seamlessly integrate their products
- 23 million small businesses in America generate 54% of all U.S. sales

*Open Source and Development Tools*

## Kareo

- Cloud-based software for doctors in private practice to compete with large operations
- Kareo Marketplace™ provides customers access apps
  - ZocDoc – marketing to new patients
  - Iron Mountain – records management solution for HIPPA compliance

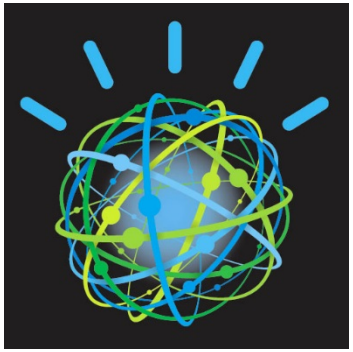

## iPhone

- June 2007 Steve Jobs & Apple launched iPhone – a hit
- ~1M sold in 1st year; after only 5-quarters surpassed Blackberry, the market leader
- One year later App Store arrived 10M downloads in fist 3-days; >1B in first year

*iPhone Turned a Consumer Product into an Ecosystem*

## IBM WATSON

- Natural language processing and machine learning to reveal insights from large amounts of unstructured data
- IBM now providing development tools for Watson



- *Fluid* makes retail recommendations
- *MD Buyline* streamlines purchasing at hospitals
- *Welltok* provides health advice to consumers

# Crowdsourcing



Distributed problem solving and production model taking a function once performed by employees and outsourcing it to an undefined network of people in an open call

## COMMERCIAL VENTURES

- Allows corporations to reduce labor costs leading to higher profit margins

iStockphoto®

INNOCENTIVE®

GOLDCORP

## DARPA

- Uses crowdsourcing for designing new technology
- In 2013 used crowdsourcing by calling for designs of a jet capable of Mach 20, growing vaccines in plants, a robot that runs faster than a cheetah, and a new tank
- Winning teams rewarded with cash grants

The FANG vehicle designed by Ground Systems for DARPA

## ONR

- Online war game where users present their solutions to a given scenario

mmowgli

massively. multiplayer. online. wargame. leveraging. the internet.

# A Brave New (Connected) World



## Age of Stand-Alone Brands is Over

- Impact of a semantic web and crowdsourcing
- Apple, Intuit, Kareo – thousands of developers enhancing products for free

## Connectedness and Availability

Kickstarter

- Funding, facilities, powerful software, supercomputing capacity and skilled talent are no longer assets to be acquired and leveraged, but resources that can be accessed by just about anyone

## The Semantic Economy

Elements include:

- Big Data – storage, processors and algorithms creating powerful analytics
- Web of Things – ubiquitous sensors and networks monitor and connect everything
- Co-Creation – designing products in partnership with customers

*A Move from Closed Innovation to Open Innovation*

*Boundaries of scale, industry and geography have become impotent*

# Christensen Revisited



## DECEMBER 2015 HARVARD BUSINESS REVIEW ARTICLE

- 20 years since the original article
- Review of tenets

1. As incumbents focus on improving their products and services for their most demanding (and usually most profitable) customers, they exceed the needs of some segments and ignore the needs of others.
2. Entrants that prove disruptive begin by successfully targeting those overlooked segments, gaining a foothold by delivering more-suitable functionality – frequently at a lower price.
3. Incumbents, chasing higher profitability in more-demanding segments, tend not to respond vigorously.
4. Entrants then move upmarket, delivering the performance that incumbents mainstream customers require, while preserving the advantages that drove their early success.
5. When mainstream customers start adopting the entrants' offerings in volume, disruption has occurred.


***DISRUPTERS TEND TO FOCUS ON GETTING THE BUSINESS MODEL, RATHER THAN MERELY THE PRODUCT, JUST RIGHT.***

# Final Thoughts on Innovation

## There is Both a Structural and a Cultural Component

- Structure
  - Enables autonomy
  - Matches profit to operating budget
  - Think about Lockheed Skunkworks as a model
- Culture
  - Need time for reflection
  - Innovation is a Team Sport: argue about concepts – don't make it personal
  - Bring recommended solutions
  - Shorten the distance to failure by rapid prototyping and testing

## Behaviors

- Five behaviors that characterize innovative leaders: associational thinking, questioning, observing, networking and experimenting.

## The Consequences …

- Look to Blackberry, Nokia, Blockbuster, Borders, Kodak, and others – companies that missed opportunities to leapfrog to the next big thing.