Research

John Kelly
Senior Vice President and Director, Research
IBM Research and Development

IBM continues to make consistent and sizable investments in R&D

<table>
<thead>
<tr>
<th>Year</th>
<th>R&amp;D Investment</th>
<th>Patents</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>$5.8B</td>
<td>~2950</td>
</tr>
<tr>
<td>2010</td>
<td>$6.0B</td>
<td>~5900</td>
</tr>
</tbody>
</table>

6% E/R
IBM Research: Supporting IBM’s Growth

- Growth Initiatives: 60%
- Base Research: 40%

- Smarter Planet
- Business Analytics
- Growth Markets
- Cloud and Next Generation Data Center
IBM Research: Services and Business Analytics

- ~1000 Researchers Globally
  - Doubled math skills 200 → 400
  - Hiring industry research experts (e.g. 5 medical doctors)
  - > 500 patents/year

- Focused on Assets
  - New 200 person joint GTS/GBS asset research lab
  - Client value and internal productivity
Services: An Assets-based Business

Client Value

Unique Capability

VOCA

VOCA for call center analytics

CBM Tools

Optimizes IT strategy for clients

Retail Analytics

Smarter commerce

CFO Dashboard

Optimizes shareholder value

CaaTS

Data cleansing (in growth markets)

Research

Internal Productivity

Smarter Workforce & Extreme Automation

NeverDown

Contingency planning

OptiServe

Strategic planning

Prospect

Résumé screening >2000/day

Catapult

AMS efficiency/quality

OptiManage

Optimizes matching skills to projects

OptiUtilize

eMigration

Optimizes SO productivity

GDF Dispatch

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OptiManage (Smarter Deployment)

- Advanced text analytics to compute matching scores
- Constraint programming to identify compatible matches (OptiMatch)
- Mathematical programming to find optimal matches
- Web-enabled user interface

Productivity

Architecture / Scenario Diagram

Recommendations for 45,000 employees per day!
eMigrate and Extreme Automation

Using Cloud-based Assets to Transform IT Services Outsourcing

Migration to Enterprise-scale Cloud Infrastructure

Today’s IT Services Outsourcing

Organization Framework (Playbook)

Migrate and Manage

Continuous Innovation Loop

Automated Migration

Automated Help Desk

Automated Service Management
CaaTS: Cleansing as a Transient Service

- Filter noise and handle semantic, syntactic and format variation
- Advanced automated methods
- Estimate accuracies (when human verification is not possible) for millions of client records

Client Value

IBM InfoSphere Quality Stage

Numerous clients in India
Exponential growth and client value in our industry have been achieved by Continual Improvement & Disruptive Innovation.
4 Technologies that Will Change the World – and IBM Will Lead

- **Compute+ Natural Language+ Analytics**
  - Deep Q&A Computers

- **Big Data**
  - 1,000 → 1,000,000 X
  - Smarter Planet 
    (Internet of Things + People)

- **Workload Optimized Systems**
  - 1000X

- **Nano Devices**
  - 1B Transistors
  - Power7 chip

- **Cognitive Computing**
  - “Synapse” devices

- **BIG/Fast**
  - Data + analytics 
    (zettabytes + milli / microseconds)

- **Exascale**
  - (Datacenter-in-a-box)
    - Massive parallelism
    - Flexible system optimization

- **Nano Systems**
  - (Systems-on-a-chip)
    - Photonics
    - DNA Transistor
From Nano Devices to Nano Systems

- **Compute+ Natural Language+ Analytics**
  - Deep Q&A Computers

- **Big Data**
  - Smart Grid

- **Workload Optimized Systems**
  - Power7 chip

- **Nano Devices**
  - 1B Transistors

- **1000X**
  - 1,000 to 1,000,000 X Smarter Planet (Internet of Things + People)

- **Learn**
  - Cognitive Computing
    - “Synapse” devices

- **Exascale**
  - Datacenter-in-a-box
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Device Structure Research Pipeline

Innovation and Disruptive Technology at Each Node

Conventional Planar Device

22/20 nm

FINFET

15/11 nm

ETSOI

Fully Depleted Devices

Si Nano-Wire

2 nm & Beyond

C Electronics

Deposited Si

HfO₂

Si NW
Vision: >1 Tbps on a 3D chip
DNA Transistor Experimental Setup

Current through metal gate

Ionic current

0.001 M KCl solution Ag/AgCl electrodes

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Roche
From Petascale to Exascale

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From Disruptive Technologies in HPC to Transfer to Commercial Leadership

- BG/L 0.3PF
- BG/P 1PF
- Roadrunner 1PF
- Blue Waters 10PF
- BG/Q ~20PF
- ~300PF
- ~1000PF

- pSeries P5
- z9 P6
- z10 P7
- zEnterprise

Relative Performance (log)

Time

Multicore SoC
High Efficiency
Scalability
Fast Network
Hybrid Architecture
Workload Optimized
From Silicon to Structure: A Holistic Approach

Modern Data Center

Machine Room Gallery

Machine Room Subfloor

Rack

Drawer

MCM

Processor
The Charge to Exascale: Future Technologies

Overall Performance = 1000X
Performance / watt = 135X
Performance / $ = 1000X
Footprint = <2%
Referenced to 1PF system

The Next Ten Years
From Big Data to Big Analytics

- Compute+ Natural Language+ Analytics
- Big Data
- Workload Optimized Systems
- Nano Devices

1,000 → 1,000,000 X
Smarter Planet (Internet of Things + People)

Program
Learn

Cognitive Computing
- “Synapse” devices

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- Data + analytics (zettabytes + milli / microseconds)

Exascale (Datacenter-in-a-box)
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Nano Systems (Systems-on-a-chip)
- Photonics
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Smarter Planet will Drive the Creation of Big/Fast Data

Number of Connected Devices

- 7 Billion in 2010
- 15 Billion in 2015
- 50 Billion in 2020

Multiple Sources: Intel, Ericsson, Gartner, etc.
Every Smarter Planet Solution Has Big/Fast Data and Needs Big/Fast Analytics
New **Big/Fast** Data Brings New Opportunities, Requires New Analytics

**Homeland Security**
- 600,000 records/sec, 50B/day
- 1-2 ms/decision
- 320TB for Deep Analytics

**Telco Promotions**
- 100,000 records/sec, 6B/day
- 10 ms/decision
- 270TB for Deep Analytics

**DeepQA**
- 100s GB for Deep Analytics
- 3 sec/decision

**Smart Traffic**
- 250K GPS probes/sec
- 630K segments/sec
- 2 ms/decision, 4K vehicles
Maximum Insight Requires Combining Deep and Reactive Analytics

- **Decision Frequency**
  - Occasional
  - Frequent
  - Real-time

- **Data Scale**
  - Exa
  - Peta
  - Tera
  - Giga
  - Mega
  - Kilo

- **Deep Analytics**
  - History
  - Predictions

- **Reactive Analytics**
  - Reality
  - Actions

- **Integration**
  - Observations
  - Feedback

- **Hypotheses**
  - Predictions

- **Decision Making**
  - Traditional Data Warehouse and Business Intelligence
Maximum Insight Requires Combining Deep and Reactive Analytics

- **Deep Analytics**
- **Reactive Analytics**
- **System s**
- **New Client Value**

- **Data Scale**
  - Exa
  - Peta
  - Tera
  - Giga
  - Mega
  - Kilo

- **Decision Frequency**
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- **Big Insights**
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From Programming to Systems that Learn

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What is Watson?

Text Search
- Frame Induction
- Concept Matching
- Deep Parsing
- Entity Extraction

Structured Search
- Sequence Matching
- Relation Extraction
- Graph Matching
- Topic Detection
- Frame Matching
- Sentence Decomposition

Statistical and Rule-based Analysis

Statistical Learning Framework
(Statistically combines disparate scores from many analytics based on Machine Learning)

UIMA for Text Analytics Standard Interoperability

UIMA-AS (Standard Messaging) for Scale-out and Speed

Linux

Power7
DeepQA: Major Leap in Precision and Confidence

- Watson Y/E 2010
- "Winners Cloud"
- Starting Point & State-of-the-Art 2007
DeepQA Can Adapt to New Domains

- DeepQA Adapted for Medical Questions

Baseline Performance With the Jeopardy System

~3 person-month effort

- This is the selective aldosterone blocker that limits ventricular remodeling after acute myocardial infarction.

- This is the most common cause of unilateral decreased vocal fremitus.
## IBM’s Innovation Approach: Watson-Style vs. Exadata-Style

<table>
<thead>
<tr>
<th>Feature</th>
<th>Watson</th>
<th>Exadata</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leap-ahead in science, opens new application areas</td>
<td><img src="https://via.placeholder.com/15" alt="Yes" /></td>
<td><img src="https://via.placeholder.com/15" alt="No" /></td>
</tr>
<tr>
<td>Amplifies human expertise and reasoning capacity</td>
<td><img src="https://via.placeholder.com/15" alt="Yes" /></td>
<td><img src="https://via.placeholder.com/15" alt="No" /></td>
</tr>
<tr>
<td>Engage humans with natural language interface</td>
<td><img src="https://via.placeholder.com/15" alt="Yes" /></td>
<td><img src="https://via.placeholder.com/15" alt="No" /></td>
</tr>
<tr>
<td>Compute over structured and unstructured information</td>
<td><img src="https://via.placeholder.com/15" alt="Yes" /></td>
<td><img src="https://via.placeholder.com/15" alt="No" /></td>
</tr>
<tr>
<td>Machine learning for continuous performance gain</td>
<td><img src="https://via.placeholder.com/15" alt="Yes" /></td>
<td><img src="https://via.placeholder.com/15" alt="No" /></td>
</tr>
<tr>
<td>Parallel computing and local memory to reduce latency</td>
<td><img src="https://via.placeholder.com/15" alt="Yes" /></td>
<td><img src="https://via.placeholder.com/15" alt="No" /></td>
</tr>
<tr>
<td>Mainly used to consolidate legacy applications</td>
<td><img src="https://via.placeholder.com/15" alt="Yes" /></td>
<td><img src="https://via.placeholder.com/15" alt="No" /></td>
</tr>
</tbody>
</table>
New Computing Architecture for Learning Systems

- New Architecture
- New Interconnect
- New Chips
- New Switch
We Are Entering a New Era

- Tabulating Era
- Computing Era
- Smart Systems Era
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