Clinical Data and Personal Data

The Internet of Health(care) Things (IoHT)

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Disclaimer: This presentation exclusively reflects the speaker’s views
Intro: What is the Internet of Things (IoT)?

The Internet of Things (IoT) is the network of physical objects or "things" embedded with electronics, software, sensors, and network connectivity, which enables these objects to collect and exchange data.
The Evolution of the IoT

The Internet Evolution
Information sharing to information generation and intelligence

The next revolution would be interconnection of every possible object on the Planet Earth, creating a New Internet called Internet of Things.

- 2003: 6.3B People, 500M Connected Devices
- 2014: 7.2B People, 11.8B Connected Devices
- 2020: 7.6B People, 50B*, 75B# Connected Devices

* based on Cisco predictions
# based on Morgan Stanley
Data in the IoT will come from a variety of different sources:

- **Devices & Products**: Over 50 Billion devices will be connected to the Internet-of-Things, in 2020.
- **Location**: 71% of Customers confirm location information before leaving.
- **Weather**: 3 Billion weather forecast reference points.
- **Social**: 12 Million new active mobile social users are added every second.

- **100's of TB data per hour created by connected devices**
- **$34.8 Billion location-based services revenue by 2020**
- **4th most used mobile app in the U.S.**
- **72% of adults online use Facebook**
IoT is driving digital disruption of the physical world

Accelerating advances in technology

- Cognitive Analytics
- Cloud Computing
- Pervasive Connectivity
- Product Lifecycle Management
- Embedded sensors

Are transforming every part of business

- Boosting operational performance and lowering costs
- Driving engagement and customer experience
- Creating new products and business models
- Advancing environmental leadership
Cognitive systems aren’t just programmed. They are programmed to learn from virtually every interaction and the surrounding context to unleash the potential of the IoT.

Cognitive IoT enables us to learn from, and infuse intelligence into, the physical world to transform business and enhance the human experience.

When the Internet of Things is combined with the Internet of People: Cognitive becomes a reality
Beyond Analytics → True Cognitive: Expand what’s knowable: Four Watson APIs are unlocking new insights from new data

**Natural Language Processing**
Enables interaction through natural human language and dialog

**Machine Learning**
Automates data processing and continuously monitors new data to learn and improve results

**Textual Analytics**
Enables mining of textual sources to find correlations and patterns in these vast amounts of untapped data

**Video/Image Analytics**
Enables monitoring of unstructured data from video feeds and image snapshots to identify scenes and patterns
Looking to connect…
Devices? Equipment? People?

Start with the Watson IoT Platform

- **Connect**
  - Connect to…
  - Secure connectivity
  - Manage devices

- **Information Management**
  - Store and archive data
  - Weather APIs
  - Structure and unstructured

- **Analytics**
  - Real time
  - Predictive
  - Cognitive

- **Risk Management**
  - Data protection
  - Security analytics
  - Blockchain

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IBM Watson IoT Platform

- Facilities
- Vehicles
- Home
- Transport
- Health
- Factories
Looking to optimize…
Assets? Product Development? Safety

Start with the IoT Applications

- **Facility & Space**
  - Improve space utilization
  - Reduce energy usage

- **Real Estate**
  - Reduce time to value
  - Improve lease management

- **Product Development**
  - Optimize resources
  - Increase ‘re-use’

- **Predictive Maintenance**
  - Operational risk
  - Increase reliability

- **Asset Management**
  - Life cycle management
  - Configuration management

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IBM Watson IoT Platform

- **Operations**
- **Asset Performance**
- **Facilities Mgmt**
- **Connected Products**
- **Work Mgmt**
- **Health & Safety**
- **Connected Products**
- **Health**
- **Facilities**
- **Vehicles**
- **Home**
- **Transport**
- **Factories**
Looking to transform traditional business with IoT…

- Invent new business models
- Develop differentiated solutions
- Improve operational efficiency
- Drive better customer engagement
- Utilize IBM innovation and a Consult to Run partnership
Cloud delivery models

<table>
<thead>
<tr>
<th>Public</th>
<th>Dedicated</th>
<th>Local</th>
<th>Self Managed</th>
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<tr>
<td>Shared public cloud services managed by IBM, hosted in an IBM data center</td>
<td>Private cloud services managed by IBM, hosted in an IBM data center</td>
<td>Private cloud services managed by IBM and hosted in a client data center</td>
<td>Private cloud infrastructure managed by IT in a client data center</td>
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**Platform Services**
- Bluemix

**Infrastructure Services**
- OpenStack
- Docker

**On-Premises Cloud**

**Off-Premises Cloud**
What is Watson? (I)

A cognitive computing platform that revolutionizes the way people and computers interact.

Natural Language Processing (NLP):

- Watson understands natural language the way humans use it.
- Watson can be taught, and can ingest unstructured information, such as text documents.
- Increasing capabilities in image processing.

Hypotheses generation:

- Watson generates hypotheses and provides suggested answers questions quickly.
- Watson will answer questions in natural language, the way humans do.

Machine Learning:

- Watson learns from its interactions.
What is Watson? (II)

Analytics and Insights capability falls into 3 types:

• **Knowledge-driven analytics**: E.g., Watson on Jeopardy!

• **Data-driven analytics**: E.g., pattern recognition in image and text data, modeling disease progression from medical claims data.

• **Combined data-driven and knowledge-driven analytics**: How knowledge (what publications and experts tell us) and what can be extracted from data complement each other to arrive at accurate predictive modeling.
# Watson IP core principles

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<th>IBM</th>
<th>Client</th>
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<tr>
<td>• IBM owns all IP to Watson Core.</td>
<td>• Client will own the copyright in any deliverables (usually documents) subject to IBM ownership of embedded IBM pre-existing materials (document templates).</td>
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<td>• IBM owns all IP to Cloud Infrastructure.</td>
<td>• Client will have a perpetual license to the embedded pre-existing templates.</td>
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<td>• IBM owns all future enhancements to the Watson Core and its Cloud Infrastructure.</td>
<td>• Client will retain ownership of the content it provides.</td>
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<td>• IBM needs full freedom of action for future Watson engagements.</td>
<td>• Client will own its pre-existing IP (and any derivatives) and its proprietary information.</td>
</tr>
<tr>
<td>• IBM will not use Client’s exclusive content or Client’s IP for any other purpose without Client’s consent.</td>
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Typical IP discussions in a Watson deal

Watson is delivered under IBM’s standard cloud terms – with predefined operational and security terms and must be on IBM contracts/paper.

Understand IBM’s investment in Watson & WHAT WATSON IS; IBM must retain freedom of action to ensure repeatability of offerings and our people.

Articulate how the client will access Watson.

Client owns their data (content) and copyright in insights developed from cognitive analysis of client data; IBM owns Watson and enhancements to the platform.

IBM must maintain full ownership and control over the Watson platform. To give ownership or control of any part to a client would result in multiple versions of Watson (“forking” the platform), which cannot be sustained.

IBM will not re-use a client’s private data used to train or operate a specific instance of Watson (without permission) and, if an instance has been specifically trained for a client on the client’s private data, IBM will not re-use that instance if it relies on the client’s private data. However, IBM must remain free to deploy Watson with its other clients, who may be able to develop similar or identical Insights using different data, including their own private data.
The liability regime is untested and unpredictable especially in high risk areas (e.g., aviation, connected cars, healthcare). Need to ensure that:

- You are not responsible if end users’s or third parties’ technology fails
- Your liability only covers actions or omissions under your control

Key questions:

- What is the solution?
- What is the role of the supplier in the eco-system where there is likely to be no direct contract with the ultimate end users?
- How can liability be fenced appropriately between the various component parts?

Areas of regulation to be taken into consideration:

- Product liability and consumer law
- Health and safety
- Industry standards and regulations
- Specific considerations based on use cases (e.g., supplier’s liability may be affected by the content that us uploaded into the ecosystem)
The Internet of Health(care) Things (IoHT)

«Smart Health»

- Tracking of drugs from manufacture to patient
- Remote monitoring of patient vital signs for chronic conditions and implantable devices
- Tracking of hospital equipment and instruments
- Coordinated patient care with family and carer alerts
- Lifestyle and fitness monitoring as part of wellness program
- Advance telemetry of inbound patient clinical data to hospital
- Staff access and cross infection controls
- Health insurance
IoHT applications

- IoHT is a heterogeneous computing, wirelessly communicating system of apps & devices, connecting patients & healthcare providers to diagnose, monitor, track and store vital statistics, medical data and other information.
  - “Telehealth” aka “Telemedicine”: The delivery of healthcare services and clinical information to remote locations

Examples

- Any wearable technology device
- Sensors embedded in medical equipment, dispensing systems, surgical robots and device implants
- Headsets that measure brainwaves
- Clothes with sensing devices
- Pulse oximeters
- Monitoring (glucose, ECG, BP, elderlies, patient behavior, stress monitoring, social activities, preventive healthcare & continuous multiparameter, different therapies, improve drug discovery and development)
- Improving processes (finding people and equipment, tracking hospital equipment, patient ID and tracking, preventing medication errors, tracking samples, e.g., blood samples, anti-counterfeit measures, product recalls, tagging implants and remote charging of batteries)
Personalized Medicine

Putting the patient at the center of their health system
“Watson Health” – building innovative solutions

- **ONCOLOGY & GENOMICS**
  - Watson for Genomics
  - Watson for Oncology
  - Clinical Trial Matching for Oncology

- **GOVERNMENT**
  - Social Program Management
  - Health & Human Services
  - Next Generation Program Integrity

- **LIFE SCIENCES**
  - Clinical trials
  - Watson for Drug Discovery
  - Watson for Patient Safety

- **VALUE BASED CARE**
  - Next Generation Population Health Suite
  - Next Generation Payer Analytics
  - Next Generation Provider Portable Analytics

- **IMAGING**
  - Watson Imaging for cardiac disease
  - Voice to Report (V2R) for Cardiologists and Radiologists
  - Cognitive Radiology Advisor

**Offerings in development**
- Offerings currently available
- Offerings available; additional cognitive integration in process
- Offerings in development

**Key Technologies**
- Highly Adaptable Cognitive API Services
- Deep Learning Technology
- Sequence Learning Capabilities
- Natural Language Processing Technology
- Highly Domain-specific Annotation and Curation
IoT for retail – asset health

Asset health
Store analytics solution

- Diagnostic and predictive analytics
- IoT-enabled fault detection
- Work order integration
- Reduced operating costs
- Reduced energy footprint
- Optimum performance

Lighting | HVAC | Equipment | Checkout | Shelving | Security | Layout
Protein pathways: Exploratory concepts are classified and relationships defined

- **Aspirin** is an antiplatelet indicated to reduce the risk of myocardial infarction.
  - Known side effects include gastrointestinal (GI) pain, GI upset, ulcers, GI bleeding, and nausea.

- **Valium or Diazepam** is a benzodiazepine derivative, indicated for the treatment of anxiety, muscle spasms.
  - May cause depression, suicidal ideation, hyperactivity, agitation, aggression, hostility...

**Annotator Logic**
- Drug = entity
- Side effect = entity association cause
- Cause = relating verb
- Rule = 1 drug to 1 side effect

**Apply Annotators to Text**
- Aspirin is an antiplatelet indicated to reduce the risk of myocardial infarction.
  - Known side effects include gastrointestinal (GI) pain, GI upset, ulcers, GI bleeding, and nausea.

**Watson Creates Knowledge Graph**
- GI Pain
- Aspirin
- Valium
- Depression
Protein pathways: Exploratory knowledge is reviewed and statistics added

Ingest
Learn
Test

Question
What genes contribute to developing colon cancer?

Search Corpus
- Side Effects
- Lab Notes
- Genes
- Publications
- Drugs
- Animal Models
- Clinical Trial Data

Extract Evidence

Score & Weigh
- Quantity
- Proximity
- Relationship
- Domain Truths/Business Rules

Learn
Exploring scientific literature

Report for igf1

Medline Articles  Relationships

**regulation positive**

**tnf**

12930919 Insulin-like growth factor-I promotes maturation and inhibits apoptosis of immature cord blood monocyte-derived dendritic cells through MEK and PI 3-kinase pathways

On the contrary, neutralizing TNF-alpha significantly increased the IGF-I-induced up-regulation of CD83 and CD40.

By Liu Enmel E | Jan 19 2004

8514650 Hyaluronate activation of CD44 induces insulin-like growth factor-1 expression by a tumor necrosis factor-alpha-dependent mechanism in murine macrophages

TNF alpha and IL-1 beta mRNA expression preceded IGF-1 protein synthesis, and TNF alpha, but not IL-1 beta, was found to directly stimulate IGF-1.

By Noble P W PW | Jan 21 1993

20093690 Tumor necrosis factor-alpha (TNF-alpha) inhibits insulin-like growth factor-I (IGF-I) activities in human trophoblast cell cultures through IGF-I-insulin hybrid receptors

Taken together, these findings indicate that TNF-alpha induces a loss of sensitivity to stimulation by IGF-I, through reducing amounts of HRT and the stimulation of HRT tyrosine kinase activity by IGF-I.

By Hashimoto Reiko R | Jan 28 2010

**regulation negative**

**tnf**

8540192 Tumor necrosis factor alpha inhibits transcriptional activity of the porcine P-450 11A insulin-like growth factor response element

While IGF-I treatment increased the binding activity of both factors, TNFalpha specifically inhibited the IGF-I-stimulated binding activity of P2.

We conclude that TNFalpha inhibits the transcriptional activity of the porcine P450acc IGFRE by preventing IGF-I-stimulated binding of P2.

By Urban R R JR | Jan 09 1997
Responsibilities

- **Patients**
- **Customer**
- **Hospital**
- **IBM**

**Analog:** Physician patient interaction

**Customer**

3rd Party Service Provider

Cloud in Switzerland

- **Patient identity**
- **Conversation history**
- **Raw & Processed data**
- **EMR**

**Physician**

Dashboard

EMR

**Hospital**

Bluemix Cloud in UK

- Expert system
- Physiological model
- Machine learning
- Image analysis

**Meta-data**
Anonymization is becoming increasingly ineffective in the world of big data

- Examples where it has apparently been possible to identify individuals in anonymized datasets
- Recent MIT study looked at records of 3 months of credit card transactions for 1.1 mio people and claimed that, using the dates and locations of 4 purchases, it was possible to identify 90 percent of the people in the dataset

It may not be possible to establish with absolute certainty that an individual cannot be identified from a particular dataset, taken together with other data that may exist elsewhere

The issue is not about eliminating the risk of re-identification altogether, but whether it can be mitigated so it is no longer significant

Organizations should focus on mitigating the risks to the point where the chance of re-identification is extremely remote

The range of datasets available and the power of big data analytics make this more difficult, and the risk should not be underestimated. But that does not make anonymization impossible or ineffective.
Anonymization

Data Type:
- Pseudo-anonymized labeled with patient number
- Identified labeled with patient identity

Contains link between patient number and patient identity
Conversation might contain names

Analog: Physician patient interaction

Customer
3rd Party Service Provider
Cloud in Switzerland

Patient identity + Conversation history + Raw & Processed data + EMR

Bluemix Cloud in UK
- Expert system
- Physiological model
- Machine learning
- Image analysis

Meta-data
Activity tracking and vital sign monitoring; data exclusivity ("ownership")

Sensing
- Accelerations
- Vital signals

Edge algorithmic
- Steps
- Vital signs

Patient app
- Time domain graph
- Activity labeling

Storage
- Labeled raw data

Analytics
- Activity score / pattern

Storage
- Processed data

Dashboard
- Time domain graph

Storage
- Medical diagnosis

Sensor Data

Raw Data
pre-processed

Processed Data

Patient Label

Meta-Data

Physician Label

Data Exclusivity ("Ownership")
- Customer
- IBM
- Shared
- 3rd Party
Medical device law: Regulatory environment for IoHT

- Federal Act on Medicinal Products and Medical Devices (Therapeutic Products Act, TPA)
- Medical Devices Ordinance (MedDO)
- IoT devices and healthcare apps as «Medical devices»?
- Rather broad definition in the MedDO
  - Includes instruments, appliances, software, etc.
  - Purposes are, among others, diagnosis, prevention, monitoring or treatment of diseases, injuries and handicaps, diagnoses related to conception
- Swissmedic’s practice
  - Medical purpose for individual
  - Pure storage, communication, search or compressions does not make the MedDO applicable
- Result: CE certification procedure to assess conformity
Impact on competitive process

Interoperability, industry standards and related IP licensing approaches (I)

- Top 5 emerging IoT markets (medical/healthcare, fitness wearables, industrial, automotive, smart homes) are driven by patented IP, much of which is being applied in IoT inventions
- IoT interoperability: «The ability of two or more systems or components to exchange data and use information»
- Standard-Setting Organization («SSO»): Very powerful position
- Fair, Reasonable, And Non-Discriminatory Terms («FRAND») / Reasonable And Non-Discriminatory Terms («RAND»)
  - both meant to avoid infringement issues, and
  - both meant to encourage adoption of SEPs
  - both have, however, not prevented IoT litigation
  - SEP owners might enforce patent, copyrights and even trademarks in IP related litigation
  - FRAND / RAND related litigation (including injunctive relief, preliminary injunctions)
Interoperability and IoHT: Things to consider

- Objectives for IoHT: Share and analyze data real time to transform and improve quality of care, patient outcomes/engagement
- Interoperability among disparate devices and systems is absolutely critical

The development of standards to govern new technologies such as 5G will significantly impact the evolution of the IoHT industry and the broader application of related technologies

- The development of these technologies will come along with new regulatory obstacles calling for action and resolution
- Dealing with IP in this process must be carefully considered: Open source model underlying original blockchain model promotes broad, cross-industry approach to collaboration that, however, needs to be balanced against vendors’ interests
Thank you!

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