IIT KHARAGPUR

NPTEL ONLINE CERTIFICATION COURSES

NPTEL

E-BUSINESS

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Week 8: Lecture1

AUTOMATIC DATA CAPTURE USING RFID

We are going to learn

- Need for automatic data capture
- Comparaison of Bar code and RFID solution
- RFID Technology overview
- RFID in supply chain
- Concerns in adopting RFID technology

Need for automatic data capture

- Collection and dissemination of real-time inventory data requires integration of automatic data capture and transfer technologies.
- *Automated Identification and Data Capture* (AIDC) includes technology to identify objects, and automatically collect data about them and update the data into software systems without human intervention.
- Some examples of AIDC technologies include bar codes, RFID, smart cards, voice and facial recognition, and so forth.
- RFID: Radio Frequency IDentification

Bar code vis-à-vis RFID solution for automated data capture

Bar Code Deficiency	RFID improved solution
Line of Sight Technology	Able to scan and read from different angles and through certain materials
Unable to withstand harsh conditions (dust, corrosive), must be clean and not deformed	Able to function in much harsher condition
No potential for further technology advancement	Technology advancement is possible due to new chip and packaging technique

Bar code vis-à-vis RFID solution for automated data capture

Bar Code Deficiency	RFID improved solution
Can only identify the items generally and not as unique objects	EPC code will enable to identify up to 2^{96} items uniquely
Poor tracking Technology, labor intensive and slow	Potential to track the items in real time as they move through the supply chain.

Uses of RFID

- Smart keys
  - Access to a facility
- Agriculture
  - Livestock Tracking
- Toll roads
  - Tracking and charging
- Asset management
- Maintenance
  - Aircraft-Intelligence Tollbox
  - Equipment-Record
- Supply chain
  - Inventory and logistics

RFID technology in the supply chain

- Advanced Shipping Notices (ASN)
- Shrinkage
- Returned Goods
- Anti –counterfeit
- Product traceability in the supply chain
- Improved stock management
- Reduction in labor costs

RFID – Basic Idea

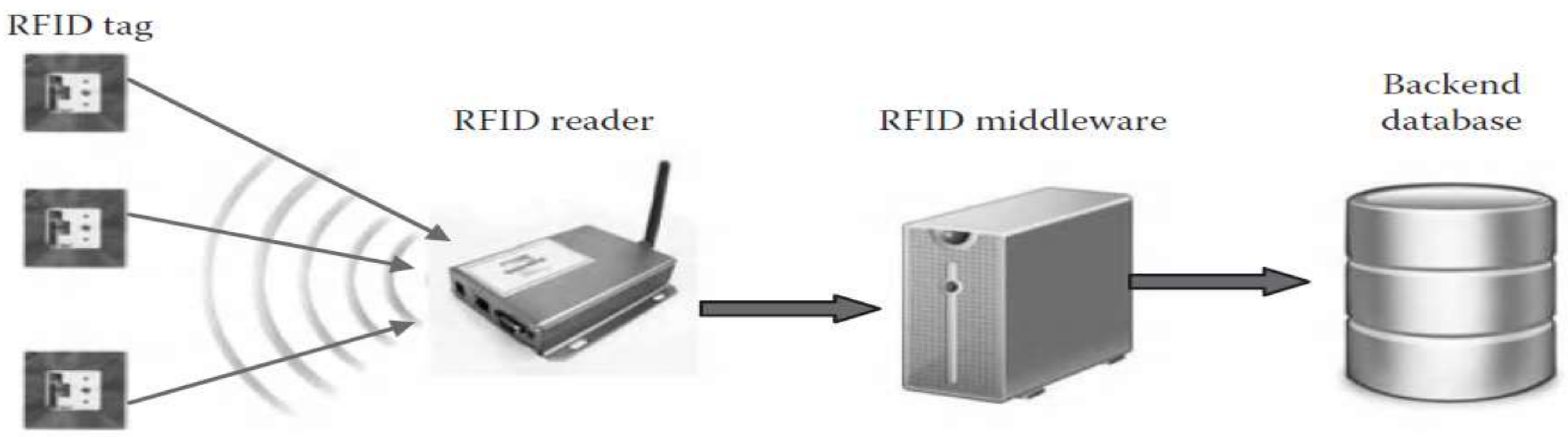
Labeling

- *code* (unique identifier) is stored in a RFID Tag
- Tag is attached to a product
- Product becomes now uniquely identifiable

Use

- Product transmits *code* from the embedded tag (active tag)
- Reader gets the message (*code*)
- *code* needs to be processed
  - corresponding action(s) to be taken here

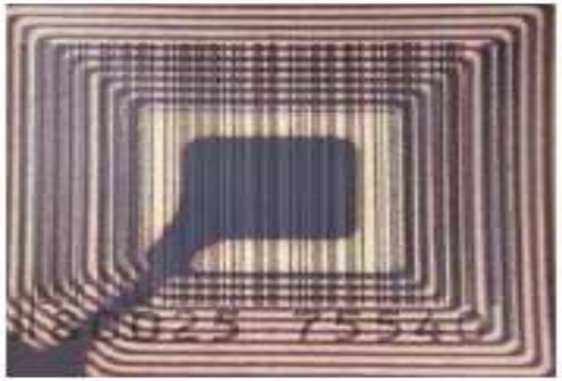
A Typical RFID Setup

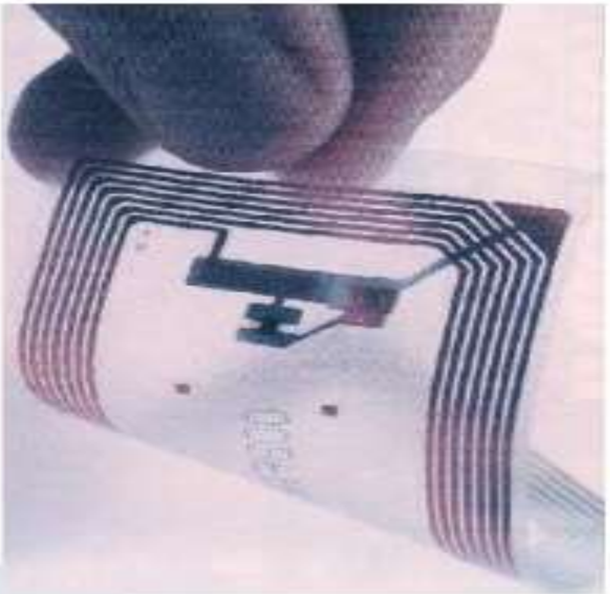


Three main elements

- RFID tag (inlay): contains data that uniquely identifies an object;
- RFID reader:, when requested, can read this unique identifier
- RFID middleware, which processes the data acquired from the reader and then updates it to the backend database or ERP systems.

RFID Tags






TD


ABEL HERE

RFID frequencies bands

- **Low Frequency** (125/134KHz)
- **High -Frequency** (13.56 MHz)
- **Ultra High-Frequency** (850 MHz to 950 MHz)

Classification of RFID tags based on their ability to perform radio communication

- ***Active Tags***
  - have a battery
  - batteries need to be recharged or replaced once they are discharged
  - Highest read range
  - **Most Expensive**
- ***Semi-Active Tags***
  - also contain a battery but still relies on the reader's magnetic field
  - larger range because all the energy supplied by the reader can be reflected back to the reader,
  - Medium read range
- ***Passive Tags***
  - completely rely on the energy provided by the reader's magnetic field
  - does not have a battery
  - Lowest read range

Classification of RFID tags based on their memory

- ***Read-only tags***:
- ***Write-once read-many***:
- ***Read-write tags***:

Classification of RFID Readers

- **Fixed Readers vs. Handheld Readers**
- **Single Frequency vs. Multi-Frequency**

RFID Readers

HF Reader

UHF EPC Reader

RFID in Supply Chain-EPC global Network

- Based on 5 Main Pillars:
  - Electronic Product Code (EPC)
  - ID System
  - EPC Middleware
  - Discovery Services
  - EPC Information Services (EPC IS)
- EPC:
  - Unique “object” identifier (worldwide)
  - 96-bit number
  - Extension of the Universal Product Code (UPC)

header	manufacturer	product	serial no
8 bits	28 bits > 268 Million	24 bits > 16 Million	36 bits > 68 Billion

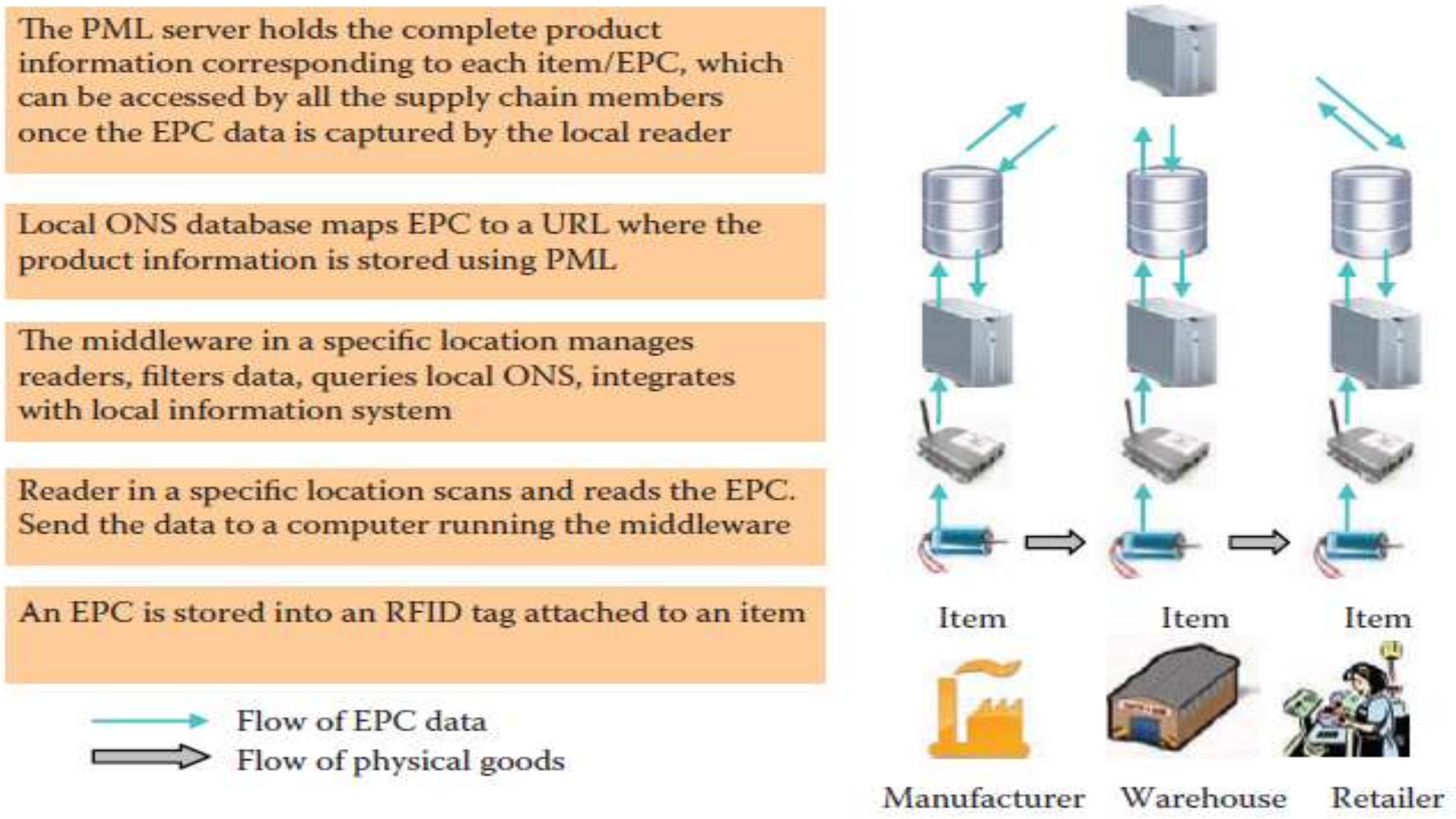
EPC Origins

- October 1999 the Auto-ID MIT
- October 2003 Auto-ID Center was closed
  - Last meeting held in Tokyo, Japan
- The Center completed its work and transferred its technology to EPCglobal (www.epcglobalinc.org), which administers and develops EPC standards going forward.

EPC global Network

- ID System
  - EPC Tags
  - EPC Readers
- EPC Middleware
- Discovery Services
  - Object Naming Service (ONS)
- EPC Information Services

Using Electronic Product Code (EPC) infrastructure in the supply chain



Week 8: Lecture2

AUTOMATIC DATA CAPTURE USING RFID AND ITS APPLICATIONS

We are going to learn

- Need for automatic data capture
- Comparaison of Bar code and RFID solution
- RFID Technology overview
- RFID in supply chain
- Concerns in adopting RFID technology

EPC global Network

- ID System
  - EPC Tags
  - EPC Readers
- EPC Middleware
- Discovery Services
  - Object Naming Service (ONS)
- EPC Information Services

Using Electronic Product Code (EPC) infrastructure in the supply chain

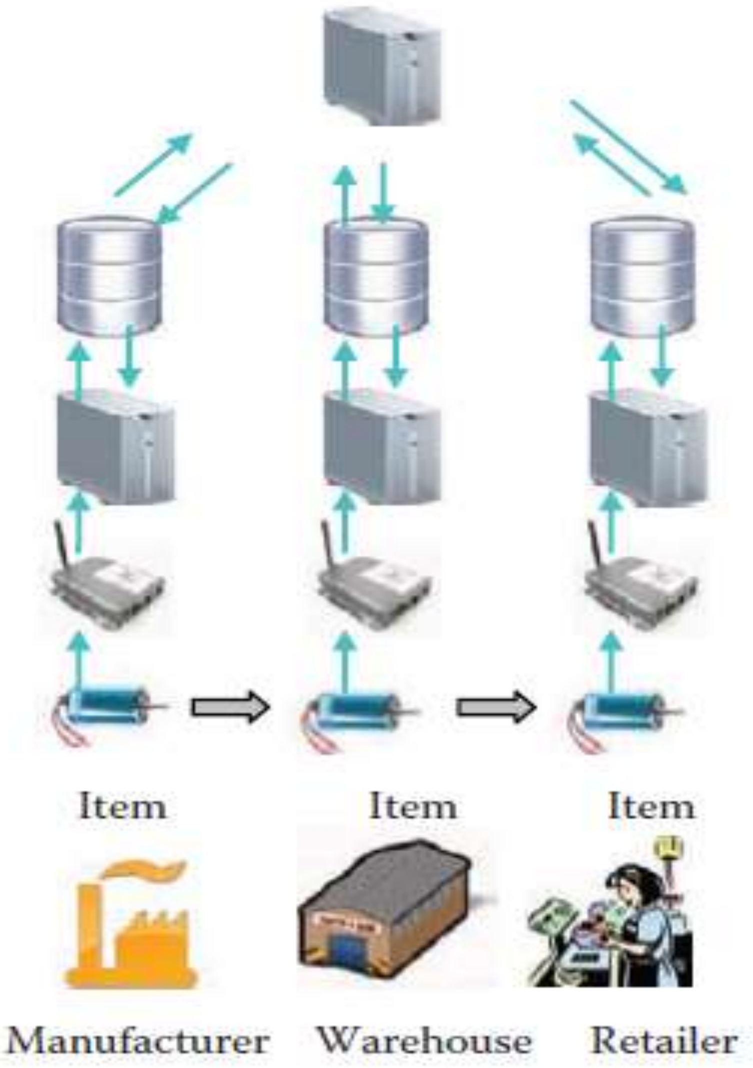
The PML server holds the complete product information corresponding to each item/EPC, which can be accessed by all the supply chain members once the EPC data is captured by the local reader

Local ONS database maps EPC to a URL where the product information is stored using PML

The middleware in a specific location manages readers, filters data, queries local ONS, integrates with local information system

Reader in a specific location scans and reads the EPC. Send the data to a computer running the middleware

An EPC is stored into an RFID tag attached to an item



→ Flow of EPC data

⇒ Flow of physical goods

How the EPC will automate the supply chain *(courtesy of EPCglobal and XPLANE)*

At the product assembly-packaging line.

1.

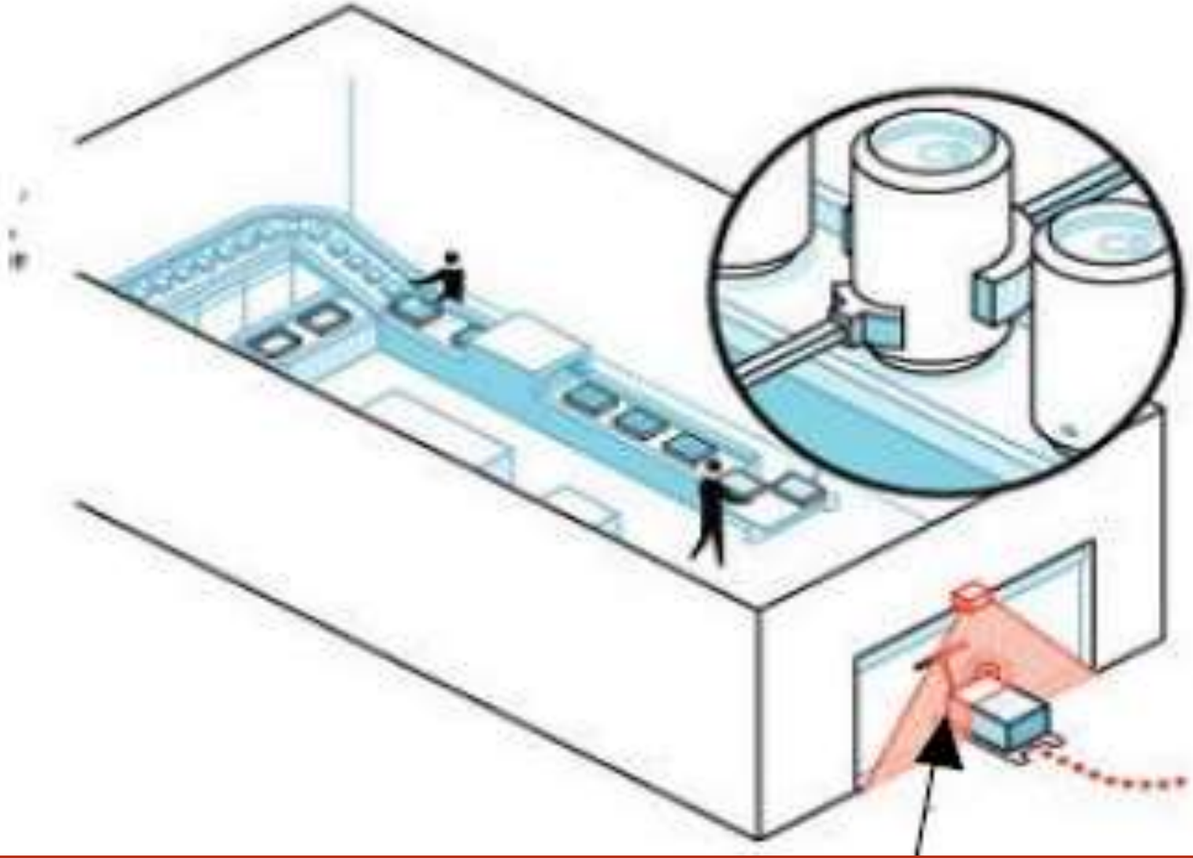
Each Item contains an RFID tag which has a unique identifier called an EPC stored in its memory.

2.

Items can now be automatically and cost-effectively identified, counted and tracked. Cases and pallets can also carry their own unique tags.

3.

As pallets leave the manufacturer, an RFID reader positioned at the loading dock door beams a radio wave that " wakes up " the tags.

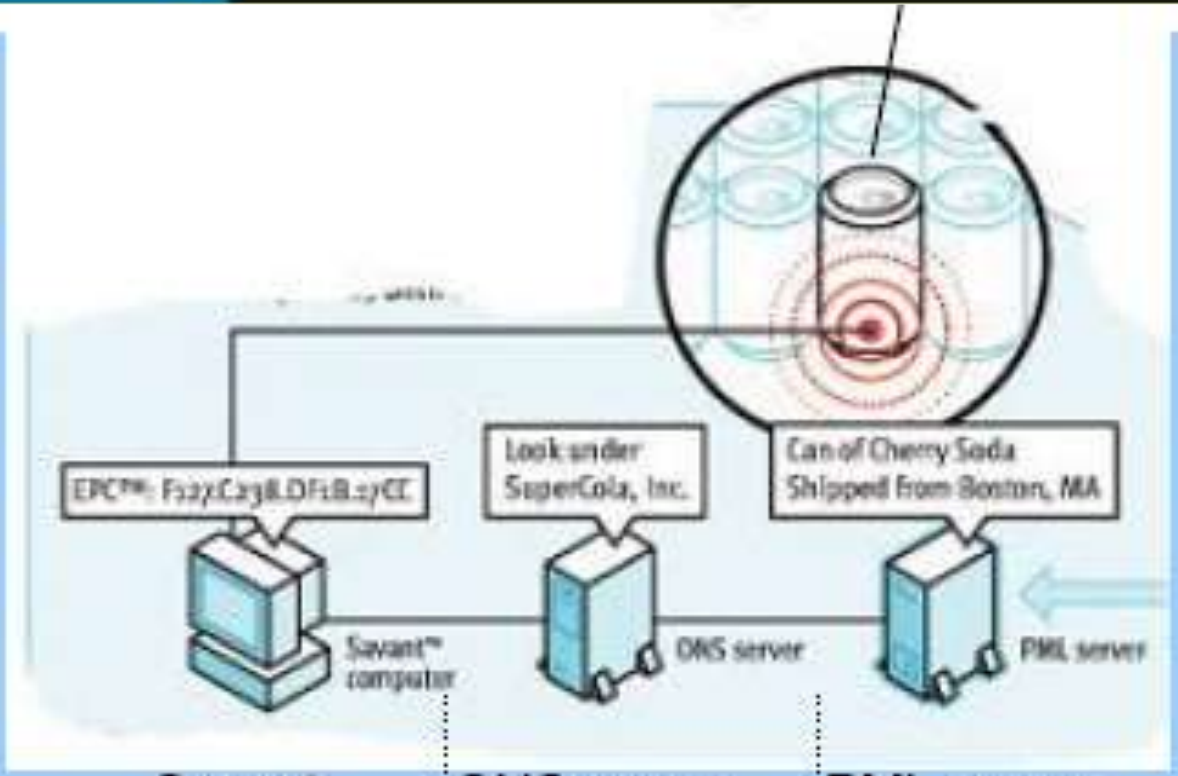


4.

a) The Tags communicate their individual EPC's to the reader, which rapidly switches them on and off in sequence (anti-collision), until all are read.

b) The reader sends the EPC to a computer called Savant ™, which in turn, sends the EPC over the internet to an Object Naming Service (ONS) database, which produces a corresponding address. The ONS matches the EPC to another server (PML), which has the full details about the product.

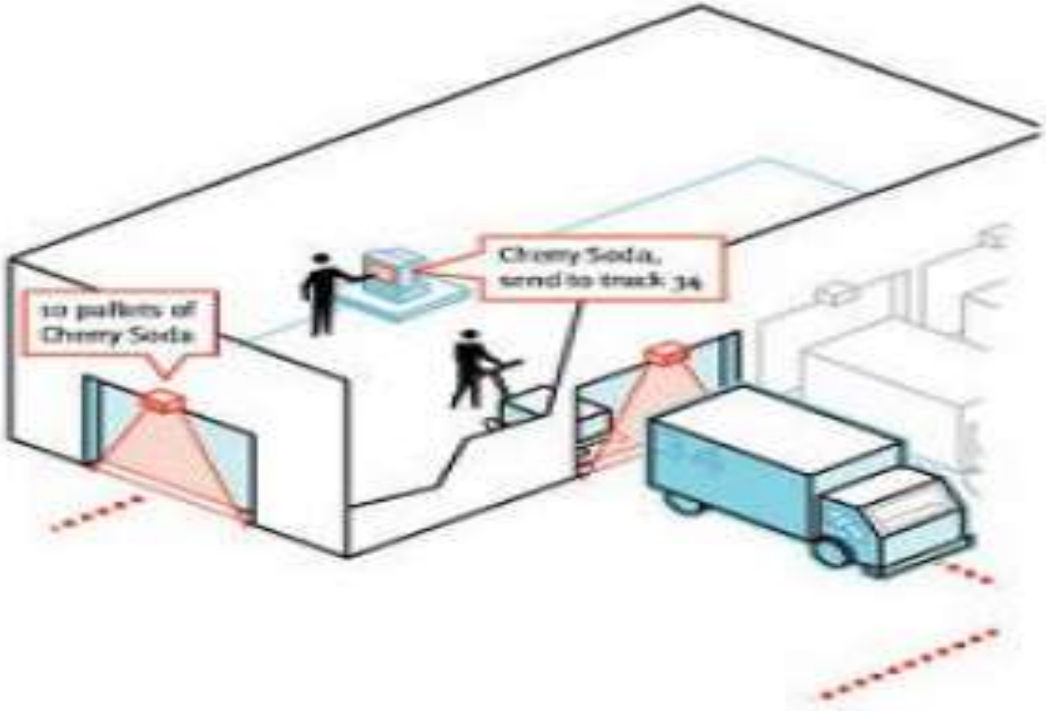
c) The PML (Physical Markup Language) server stores details about the manufacturers products. Because it knows where the product was made, if an accident involving a defect arises, the source of the problem can be tracked and the products immediately recalled.



Savant Computer	ONS server	PML server
EPC: Fxyzz3t0nn;4x;CC	Look under Super Cola Inc	Can of Cherry Soda, shipped From Boston,MA

5. At the Distribution Center

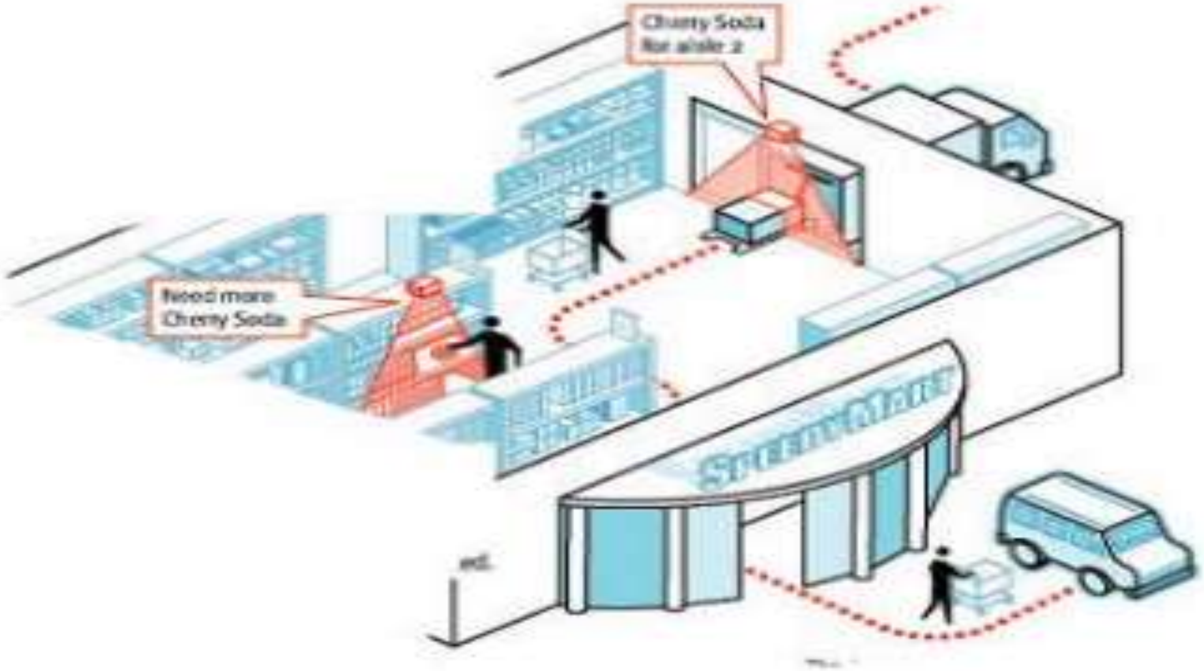
If the unloading area contains an RFID reader, there 's no need to open the packages and examine their contents. A SAVANT provides a cargo list, and the pallet is quickly routed to the appropriate truck.



6. At the Retail Store

As soon as it arrives , retail systems are updated to include every item. In this way stores can locate their entire inventory automatically, accurately and at low cost.

Reader enabled " smart shelves " can automatically order more product from the system and therefore keep stock to cost-effective and efficient levels.



Why the Push to RFID ?

- Key Industry Drivers Leading Us Toward RFID
  - Mandates such as Wal-Mart and the DOD
  - Industry Trends for Supply Chain and Manufacturing Management
  - Issue Pertaining to Process and Quality Control
  - Government Regulations

Technical Concerns with RFID

- Tag orientation: tags oriented perpendicular to the reader antenna prevent an effective communication. Varying the position of the reader or build advanced antennas less sensitive to orientation represent solutions to this problem.
- Reader coordination: several readers in proximity to each other interfere with each other.
- Product packaging independence: certain types of packaging such as metalized packaging adversely affect the tag readability.

http://diuf.unifr.ch/main/is/sites/diuf.unifr.ch.main.is/files/file/courses/eBiz_fs08/fabien_ropraz_eBusiness_RFID_Paper.pdf

Technical Concerns with RFID

- Multiple standards: several frequencies and standards have been developed for RFID tagging solutions, partly because of national frequency use restrictions and cost tradeoffs. One of the possible options to resolve this standardization problem is to build readers that can operate using multiple standards. Nevertheless, developing a global standard is necessary in order to achieve universal traceability.

Technical Concerns with RFID

- Data formats: the way data is represented in memory of rewritable tags is not standardized yet, which makes it more difficult for companies to share and interpret data, as they move through a supply chain. When the memory capacity potential of RFID has increased enough, XML may well be used for this purpose in the future.
- Electromagnetic interferences: they can be caused by physical external factors, such as machines and electric motors. In addition, liquids or metals may absorb or reflect RF signals.

Other Concerns

- Privacy concerns: RFID makes it possible to gather sensitive data about an individual without him being aware of it, as RFID can be read at a distance.
- Security concerns: The major risk with RFID issues from the low processing speed and low memory of tags, especially passive tags, which renders them computationally weak for basic cryptographic operations.

Week 8: Lecture3

GPS AND GIS IN SUPPLY CHAIN

We are going to learn

- Fundamental concepts related to GPS
- Fundamental concepts related to GIS
- GPS and GIS applications in the supply chain

Tracking the supply chain beyond RFID

- Items/SKUs/Consignments cannot be tracked using RFID if it is not under the antennae coverage
- Once the vehicle is out of the coverage it must be tracked using GPS

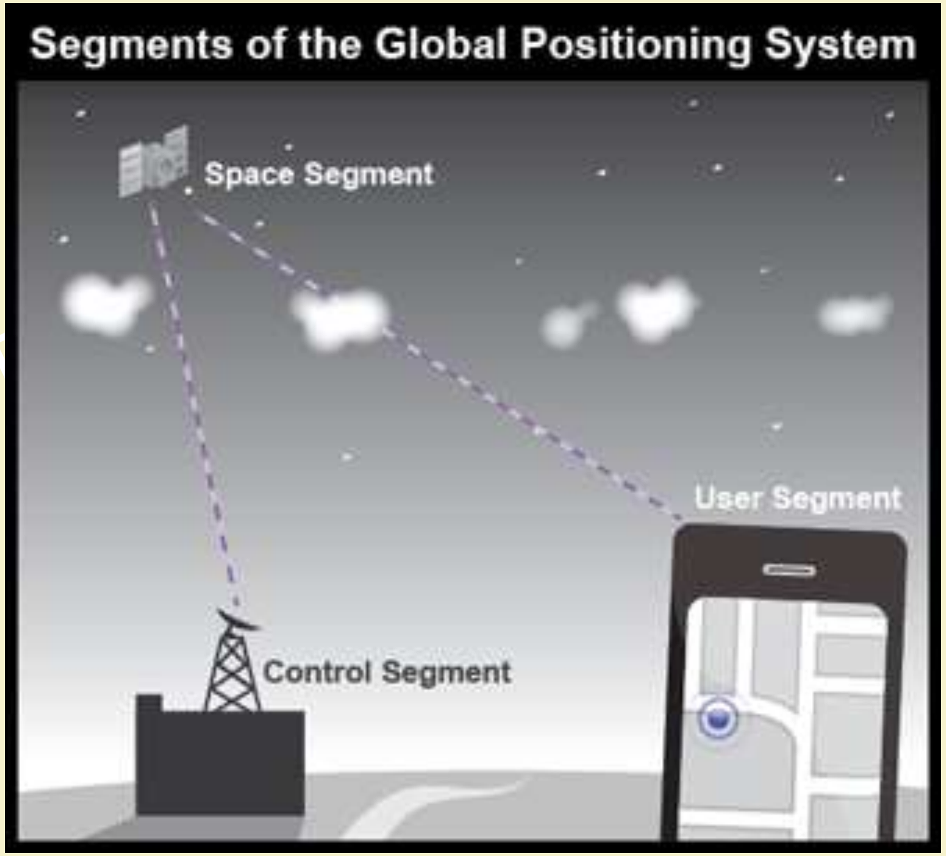
Global Positioning system (GPS)

- A space-based radio navigation system owned by the United States government and operated by the United States Air Force.
- Does not require the user to transmit any data, and it operates independently of any telephonic or internet reception
- Since 1996 GPS is free for civilian users

https://en.wikipedia.org/wiki/Global_Positioning_System

Components of GPS system

- ***The space segment***
  - Consists of 28 satellites, each in its own orbit
- ***The user segment***
  - consists of receivers, which the user can hold in his hand or mount in the car.
- ***The control segment***
  - consists of five ground stations located around the world that make sure the satellites are working properly.



http://www.loc.gov/rr/scitech/mysteries/global.html

https://www.e-education.psu.edu/geog160/node/1923

Working principle of GPS

- GPS satellites broadcast radio signals providing their locations, status, and precise time (t1) from on-board atomic clocks.
- The GPS radio signals travel through space at the speed of light
- A GPS device receives the radio signals, noting their exact time of arrival (t2), and uses these to calculate its distance from each satellite in view.

http://www.gps.gov/multimedia/poster/

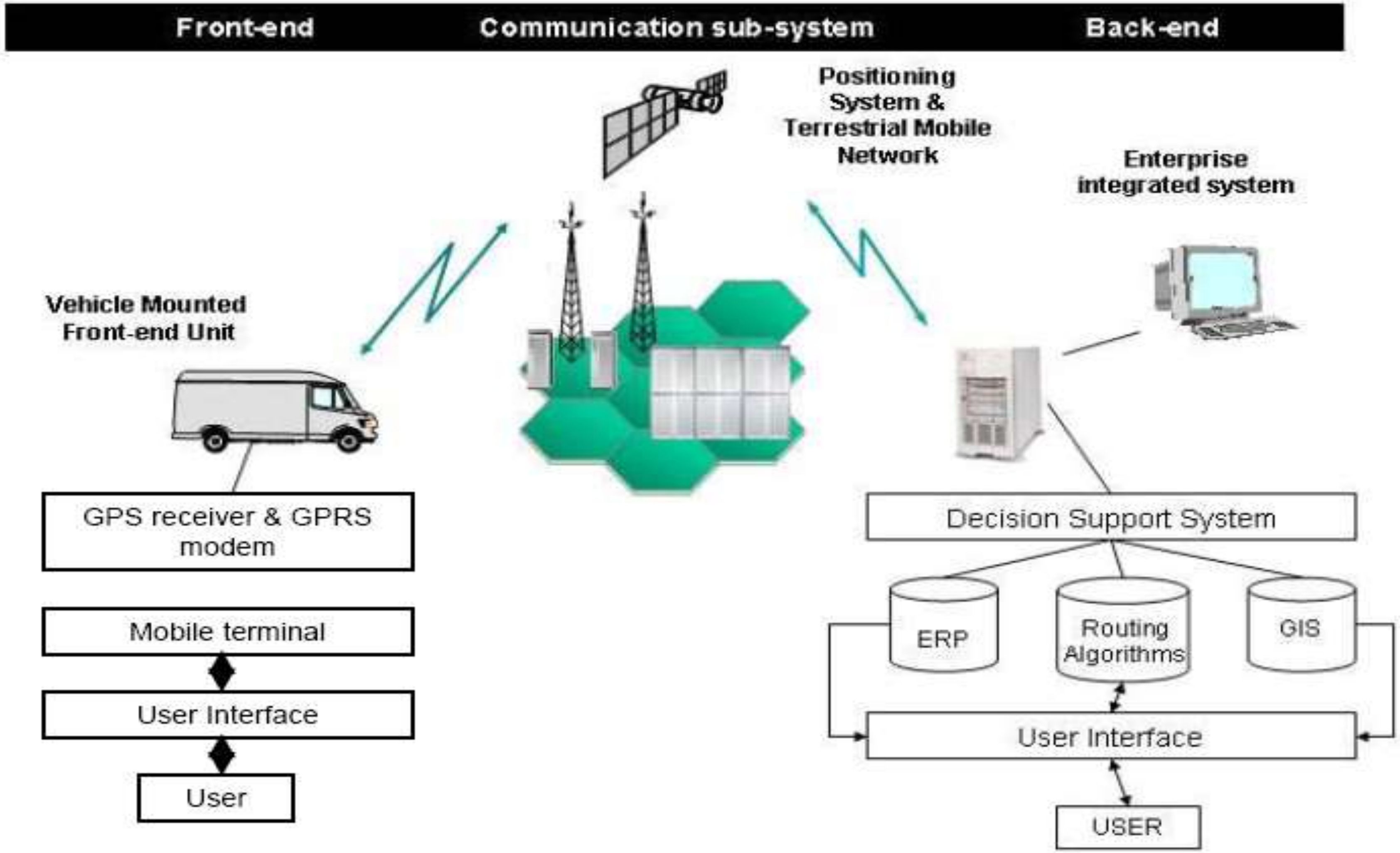
Working principle of GPS

- Distance of the GPS device from a satellite:
  - distance = rate x time
  - rate is the speed of light
  - time is how long the signal travelled through space (t2-t1)
- Once a GPS device knows its distance from at least four satellites, it can use geometry to determine its location on Earth in three dimensions.

Working principle of GPS

- The GPS Master Control Station tracks the satellites via a global monitoring network and manages their health on a daily basis.
- Ground antennas around the world send data updates and operational commands to the satellites.

Generic architecture for dynamic real-time vehicle management



G.M. Giaglis, I. Minis, A. Tatarakis, V. Zeimpekis, (2004) "Minimizing logistics risk through real-time vehicle routing and mobile technologies: Research to date and future trends", International Journal of Physical Distribution & Logistics Management, Vol. 34 Issue: 9, pp.749-764,

Integrating GPS with GIS

- GIS uses GPS technology for location purposes, but GIS adds data that allows the user to make intelligent strategic and tactical decisions.

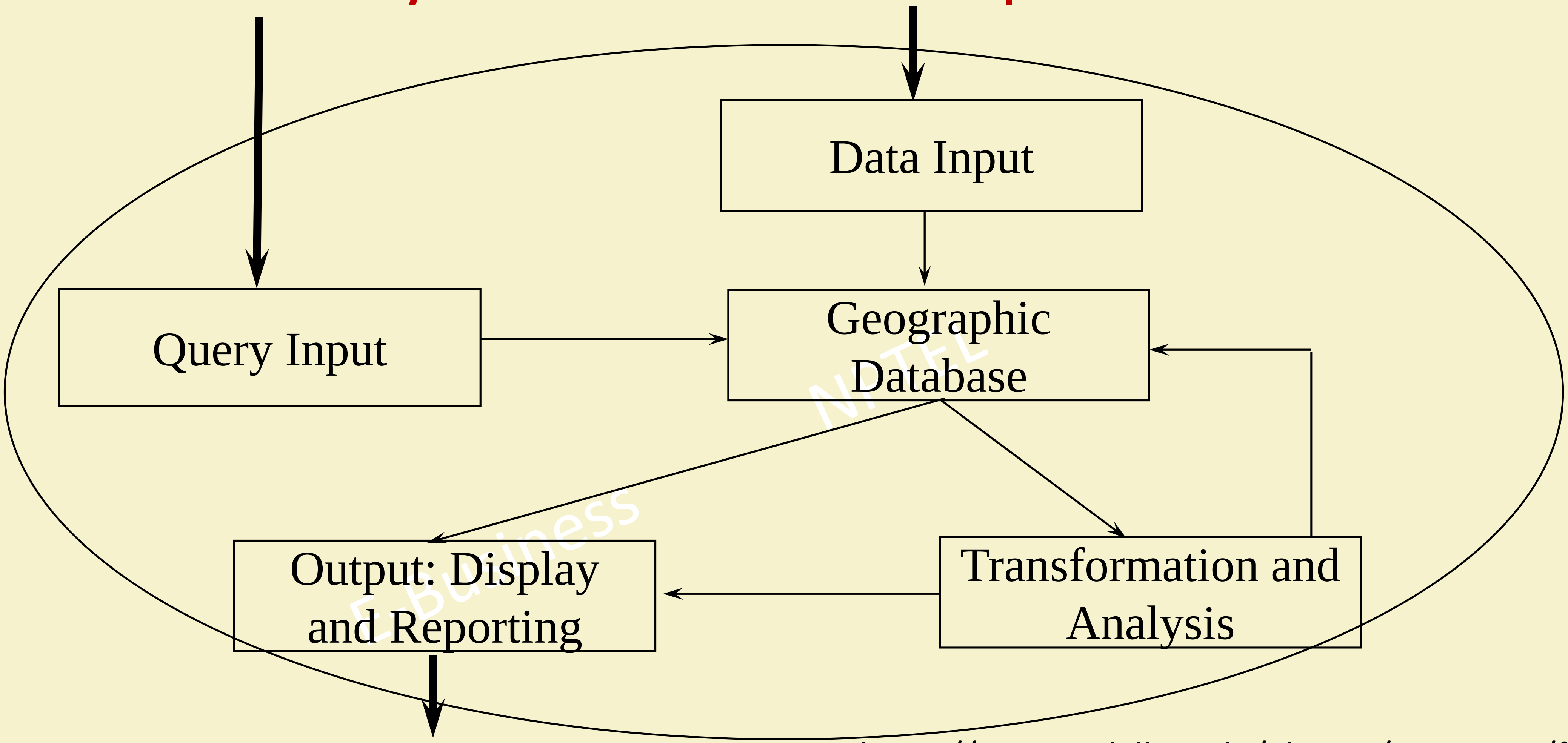
GIS: Geographical Information System

- Software systems with capability for input, storage, manipulation/analysis and output/display of geographic (spatial) information
- Geographical Information System (GIS) can be used as a database for storing transportation data.
- The primary advantage of using GIS as a database for transportation data is the fact that GIS can integrate the spatial data and display the attribute data in a user-chosen format.

GIS: Geographical Information System

- The chief sources of spatial data are the existing digitized files (e.g.: Topologically Integrated Geographic Encoding and Referencing (TIGER) files).
- The Global Positioning System (GPS) is widely being used as a tool for collecting the spatial data.
- Systems which chiefly use GPS as a spatial data source for a GIS are called as GPS-GIS integrated systems.

GIS System Architecture and Components



https://www.utdallas.edu/~briggs/poec5319/fund.ppt

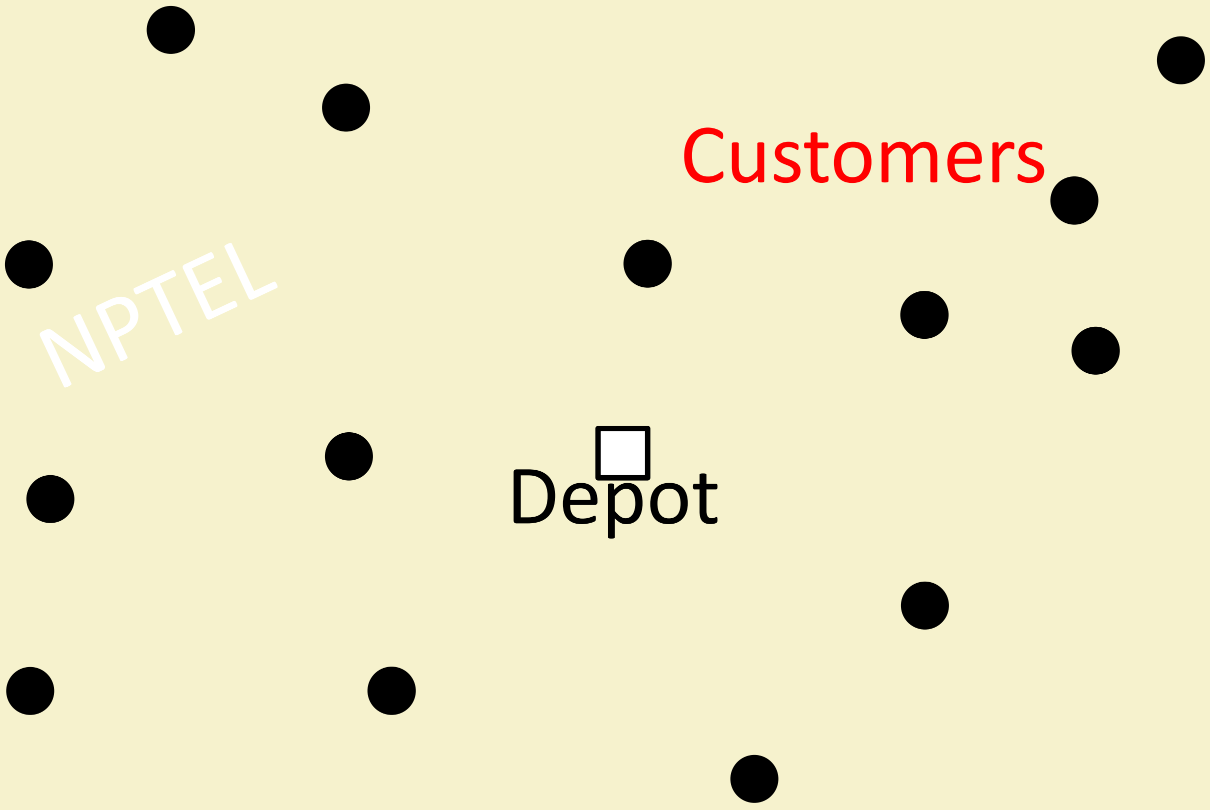
GIS. Fundamentals. Dr. Ronald Briggs. The University of Texas at Dallas

Applications of GPS-GIS Integrated system

- Automobiles
  - Fleet management
  - ***Dynamic Vehicle Routing***
  - Tracking Rental Cars
- Airline safety
  - Aviation security
- Agriculture
  - Tracking Livestock
  - Yield Monitoring
- Sports
  - Bicycle Racing
  - Golf
- Law enforcement
  - Tracking Criminals
  - Appealing Speed Tickets

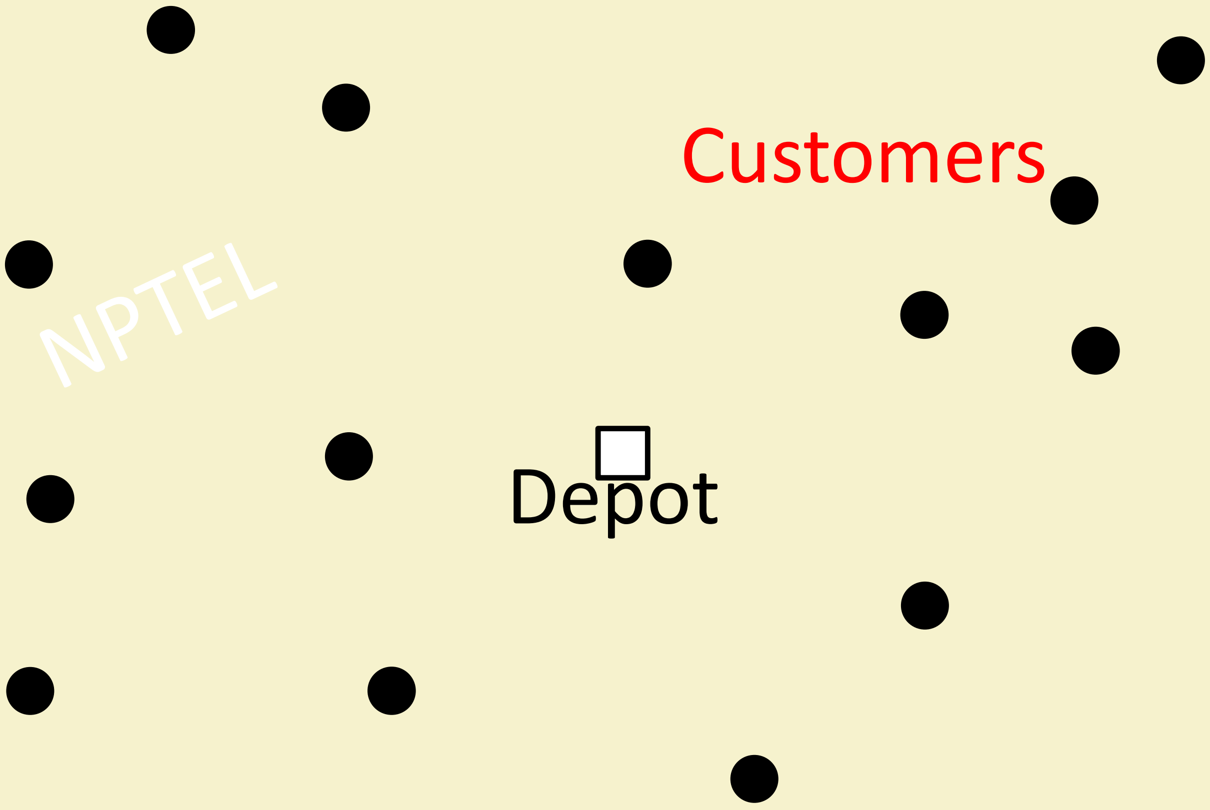
The vehicle routing problem

- What is the optimal set of routes for a fleet of vehicles to traverse in order to deliver to a given set of customers?



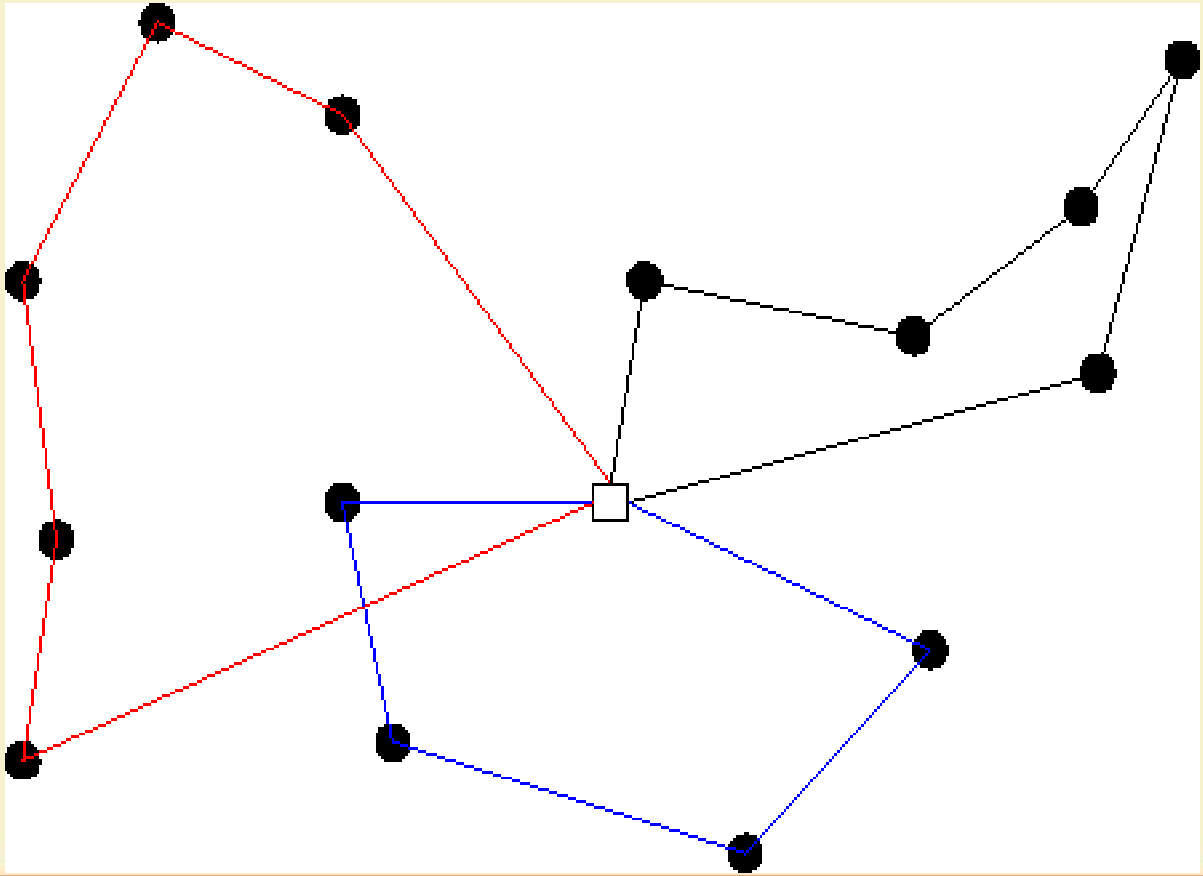
The vehicle routing problem

- The vehicle routing and scheduling problem consists of two sub-problems:
  - the customer grouping to routes (clustering)
  - the definition of the optimum tour for every route (cluster).



The vehicle routing problem

- Route is the total number of deliveries made by a single vehicle and tour is their sequence.
- The solution of these sub-problems results to the routes and tours that minimize the total transportation cost.



It has many variations

- *Capacitated Vehicle Routing Problem (CVRP)*- VRP with the additional constraint that all vehicles within the fleet have a uniform carrying capacity of a single commodity. The commodity demand along any route assigned to a vehicle must not exceed the capacity of the vehicle.

- *Vehicle Routing Problem with Time Windows (VRPTW)*- VRP with the additional constraint that each customer or stop has an associated, fixed time interval during which pickups or deliveries must be made.

- *Capacitated Vehicle Routing Problem with Time Windows (CVRPTW)*- VRP that includes both vehicle capacities and time windows (hybrid version of the CVRP and the VRPTW).

- *Multiple Depot Vehicle Routing Problem (MDVRP)*- VRP with multiple depots and vehicle fleets. All stops must be assigned to a single depot/fleet in order to minimize service costs.

- *Periodic Vehicle Routing Problem (PVRP)*- VRP that allows service to be extended over *M* days, instead of single-day service.

- *Split Delivery Vehicle Routing Problem (SDVRP)*- VRP in which some customers may actually be serviced by more than one vehicle.

- *Stochastic Vehicle Routing Problem (SVRP)*- VRP in which one or more problem components are random or present with some probability,.

- *Vehicle Routing Problem with Satellite Facilities (VRPSF)*- VRP with the inclusion of remote facilities throughout the transportation network, which may be used to re-supply or unload vehicles along their route. This enables capacitated vehicles to handle routes with larger demands before returning to the central depot.
- Real time vehicle routing

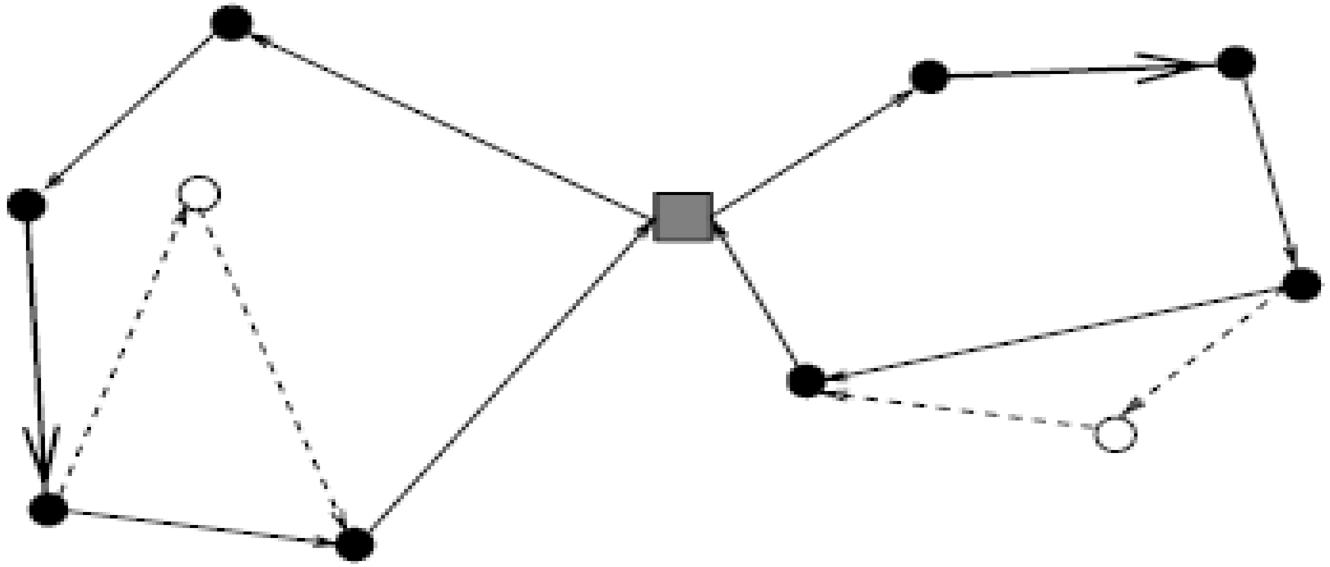
The Static Vehicle Routing Problem

- All information relevant to the planning of the routes is assumed to be known by the planner before the routing process begins.
- Information relevant to the routing does not change after the routes have been constructed.

Dynamic Vehicle Routing Problem setting

- Not all information relevant to the planning of the routes is known by the planner when the routing process begins.
- Information can change after the initial routes have been constructed.
- More complex problem than static VRP
- Need real time algorithms

A dynamic VRP



Advance request customer (static)

Immediate request customer (dynamic)

Current position of vehicles

Planned route

New route segment

Examples of DVRP

- **Dynamic fleet management:** Several large-scale trucking operations require real-time dispatching of vehicles for the purpose of collecting or delivering shipments. Important savings can be achieved by optimizing these operations.

- **Vendor-managed distribution systems:** In vendor-managed systems, distribution companies estimate customer inventory level in such a way to replenish them before they run out of stock. Hence, demands are known beforehand in principle and all customers are static. However, because demand is uncertain, some customers (usually a small percentage) may run out of stock and have to be serviced urgently.

Examples of DVRP

- **Couriers:** Long-distance courier need to collect locally outbound parcels before sending them to a remote terminal to consolidate loads. Also, loads coming from remote terminals have to be distributed locally. Most pick-up requests are dynamic and have to be serviced the same day if possible.
- **Rescue and repair service companies**: There are several companies providing rescue or repair services (broken car rescue, appliance repair, etc.)
- **Dial-a-ride systems:** Dial-a-ride systems provide transportation services to people between given origin–destination pairs. Customers can book a trip one day in advance (static customers) or make a request at short notice (dynamic customers).

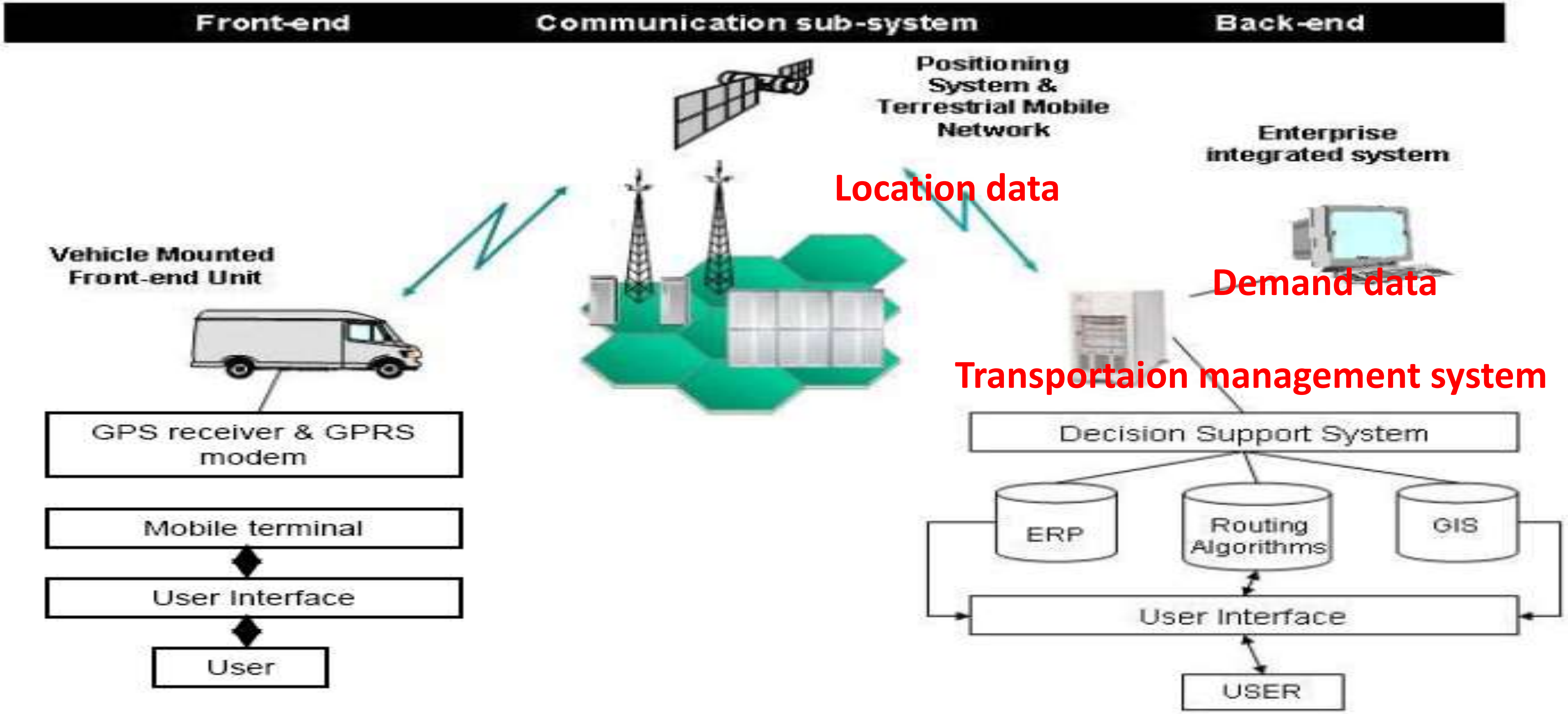
Examples of DVRP

- **Emergency services:** Emergency services comprise police, fire fighting and ambulance services. By definition, all customers are dynamic. Moreover, the demand rate is usually low so that vehicles become idle from time to time. In this context, relocating idle vehicles in order to anticipate future demands or to escape from downtown rush hour traffic jam is a major issue.

- **Taxi cab services:** In taxi cab services, almost every customer is dynamic. As in emergency services, relocating temporary idle vehicles is an issue.

Getting real time data

- Demand data
  - EDI
  - Web services
- Location data
  - GPS
  - GIS


Front-end
Communication sub-system
Back-end
Positioning System & Terrestrial Mobile Network
Enterprise integrated system
Location data
Demand data
Vehicle Mounted Front-end Unit
Transportaion management system
GPS receiver & GPRS modem
Mobile terminal
User Interface
User
Decision Support System
ERP
Routing Algorithms
GIS
User Interface
USER

Week 8: Lecture4

SENSORS AND IOT:

TRACEABILITY ACROSS THE SUPPLY CHAIN

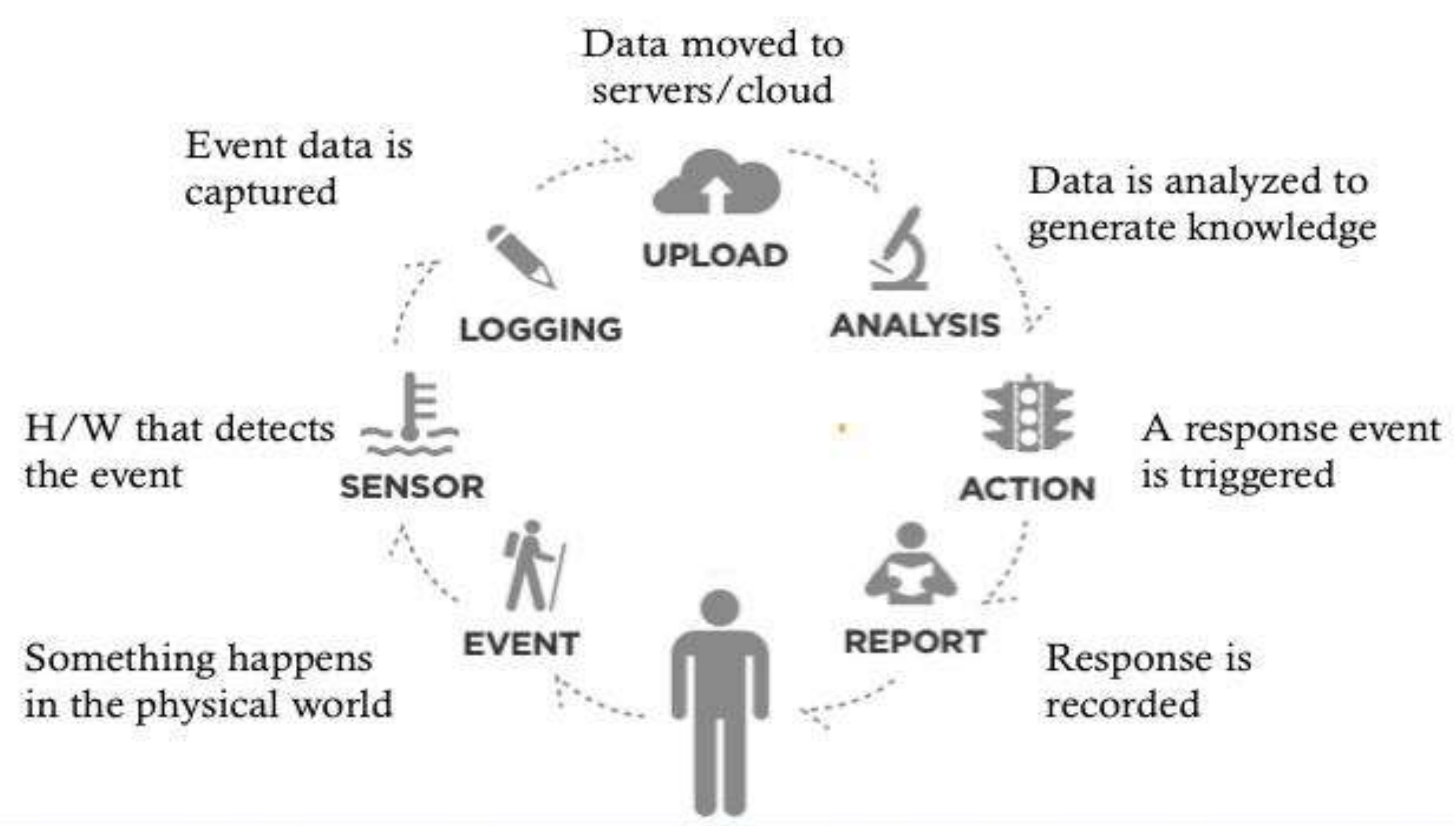
We are going to learn

- Fundamental concepts related to sensors and IoT
- Applications in supply chain traceability

What are they

- Sensor
  - converts physical phenomenon e.g. heat, light, motion, vibration, and sound into electrical signals
- Sensor node
  - basic unit in sensor network
  - contains on-board sensors, processor, memory, transceiver, and power supply
- Sensor network
  - consists of a large number of sensor nodes
  - nodes deployed either inside or very close to the sensed phenomenon
- The Internet of Things (IoT)
  - the network of physical objects—devices, vehicles, buildings and other items embedded with electronics, software, sensors, and network connectivity—that enables these objects to collect and exchange data.

Path of a Connected Device



https://www.linkedin.com/pulse/20140613140238-7109282-internet-of-things-and-its-impact-on-supply-chain-management

Defining IoT

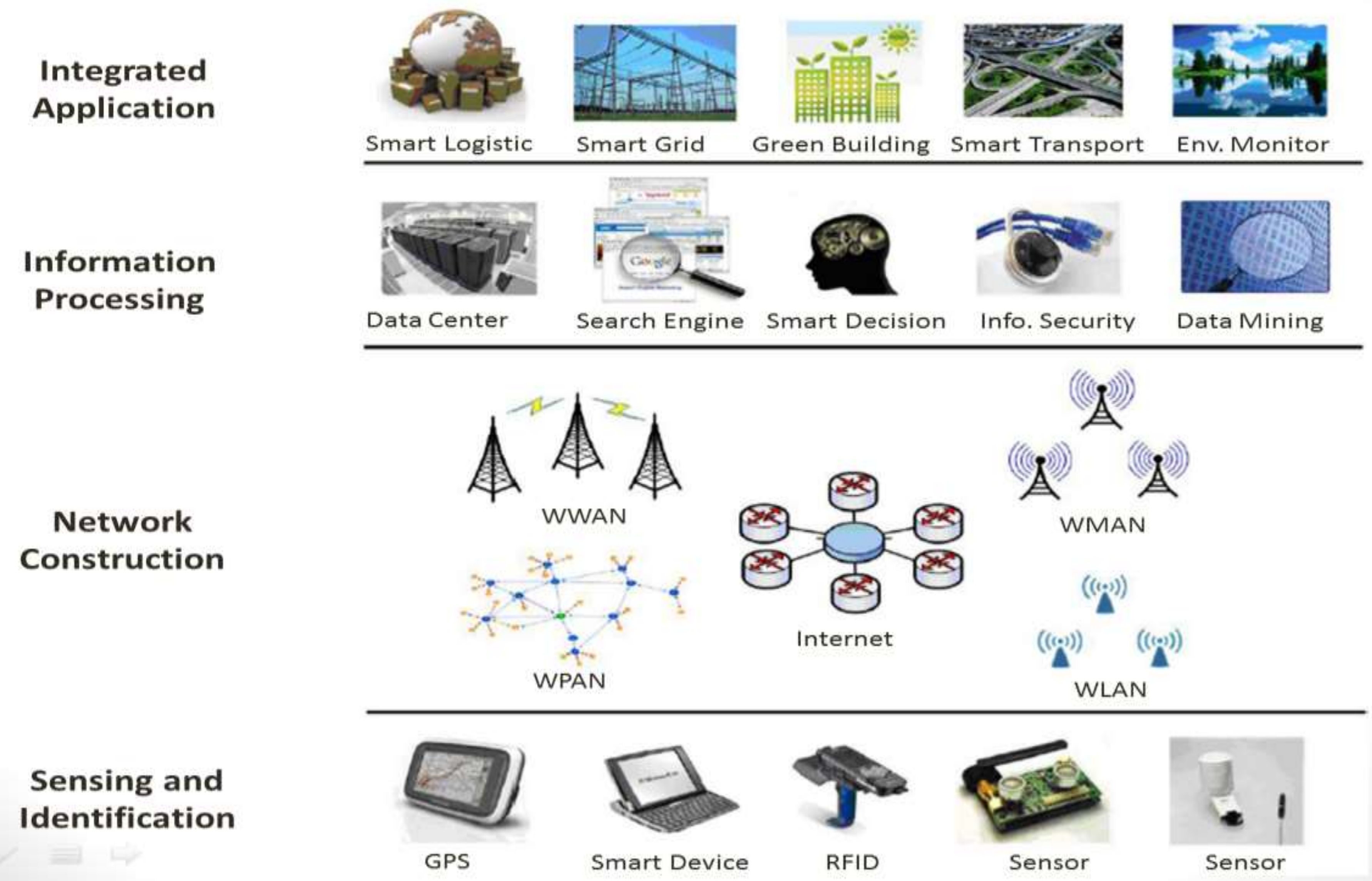
- The Internet-of-Things (IoT) is a vision of connectivity for anything, at anytime and anywhere, which may have an impact on our daily life dramatically as what the Internet has had in the past two decades (ITU 2005).
- *"Things having identities and virtual personalities operating in smart spaces using intelligent interfaces to connect and communicate within social, environmental, and user contexts"*

(European Commission Information Society, 2008)

Defining IoT

- Synonymous with the terms such as "*ambient intelligence*", "*ubiquitous network*", "*ubiquitous computing*", "*pervasive computing*", and "*cyber-physical systems*".
- Key enabling technologies
  - Radio frequency identification (RFID), wireless sensor network (WSN), machine-to-machine communication (M2M), human machine interaction (HMI), middleware, web service, information systems, etc.

Four layer model of IoT



www.cs.ust.hk/~qianzh/FYTGS5100/fall2013/notes/Chapter1-IoT.ppsx

IoT Challenges

- Technology standardisation
- Managing rapid innovation
- Privacy & security
- Governance

Tracking a tracing in the supply chain

- Tracking: Current status and the future
- Tracing: The past

Traceability

- "The ability to trace and identify the history, distribution, location and application of products, parts and materials; to ensure the reliability of sustainability claims in the areas of human rights, labour (including health and safety), the environment and anti-corruption."

http://sustainable.org.nz/sustainability-news/traceability-in-supply-chains-why-it-matters#.WWBibWiGM2w

Need for traceability

Values and Efficiencies	Stakeholder Pressure	Regulation	Global Alignment
1. Reducing risk 2. Operational efficiencies and process consistency 3. Securing supply 4. Supplier selection and supplier relationships 5. Reputational benefits	6. Meeting stakeholder demands for more product information 7. Ensuring sustainability claims are true	8. Meeting legal requirements	9. Standardization of expectations, processes and systems 10. Ensuring security of natural resources

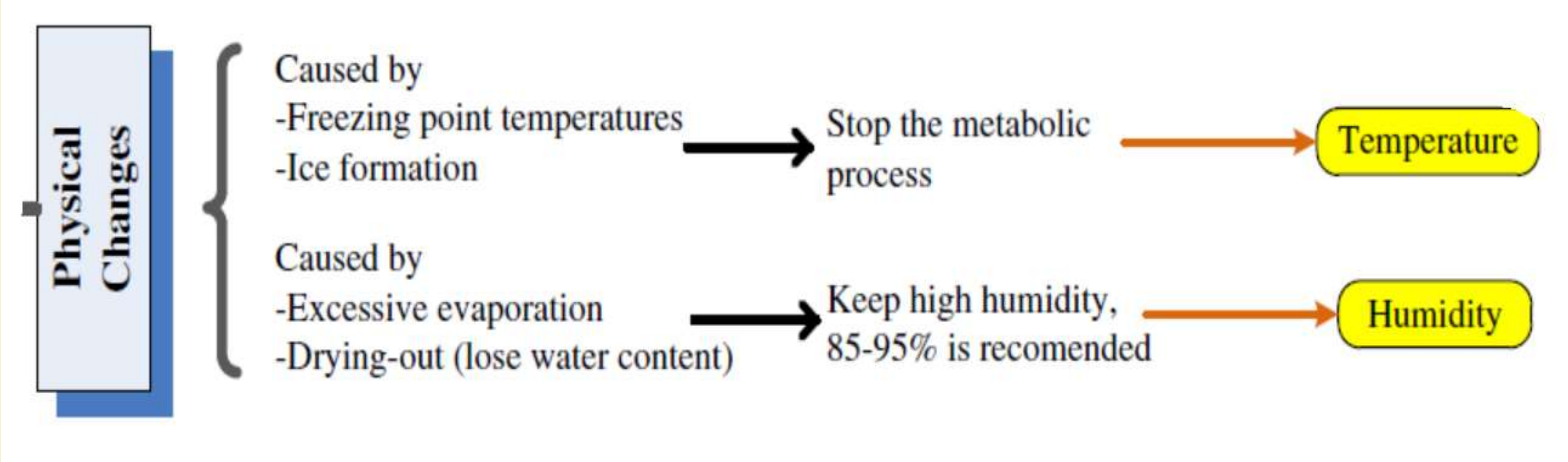
IoT in Food Traceability: An illustration

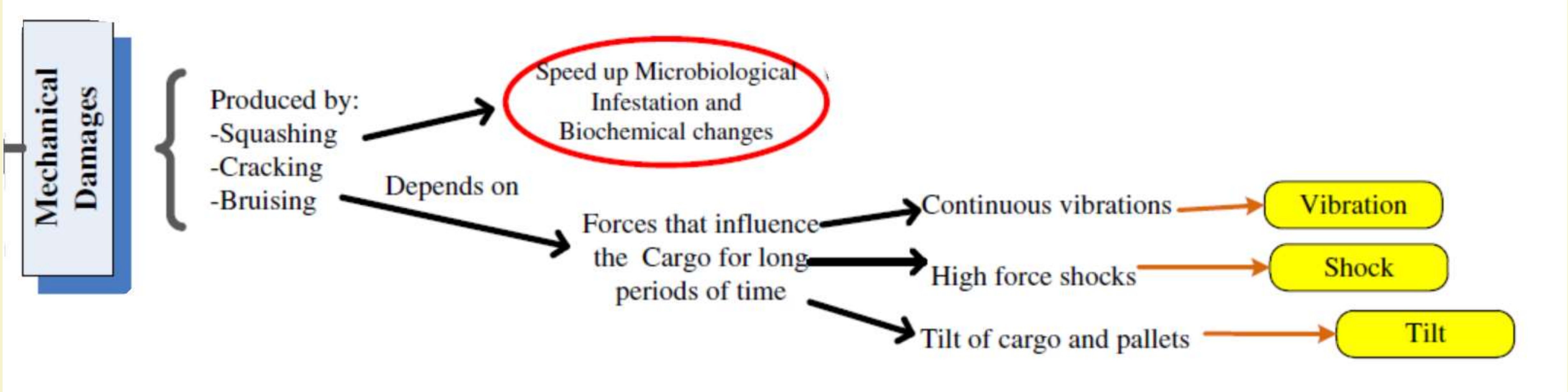
Pang, Z., Chen, Q., Han, W. and Zheng, L., 2015. Value-centric design of the internet-of-things solution for food supply chain: value creation, sensor portfolio and information fusion. *Information Systems Frontiers*, pp.1-31.

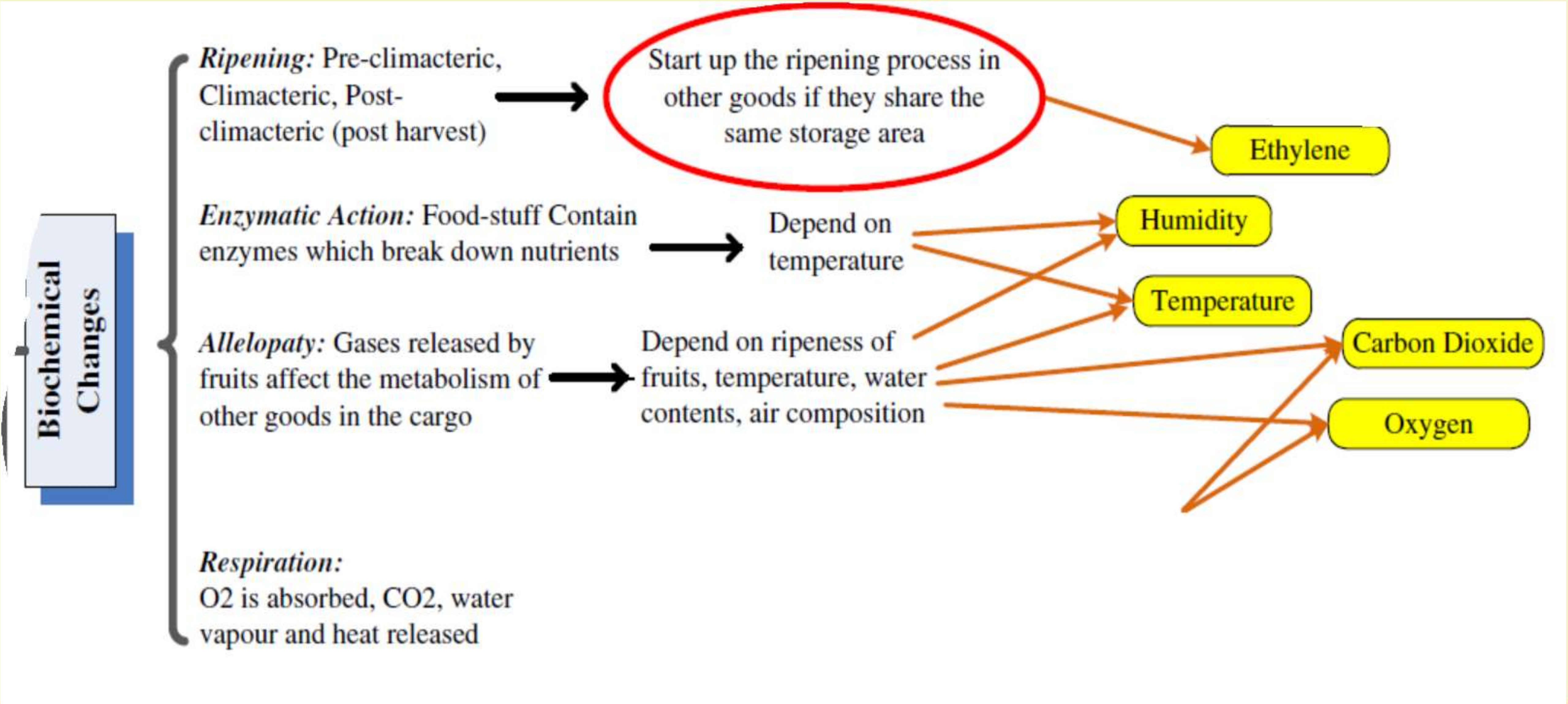
Traceability in food

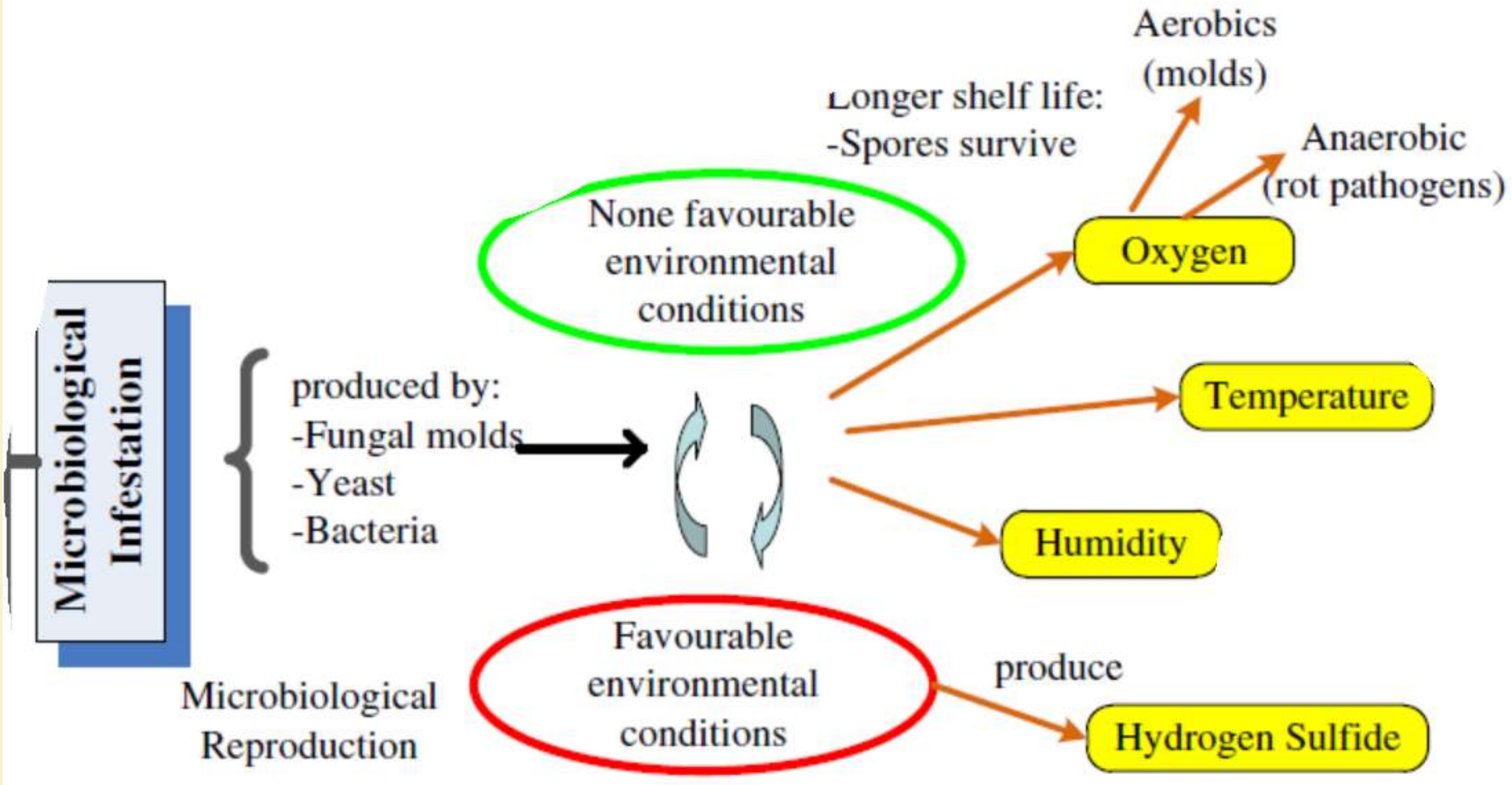
- "Traceability" means the ability to track any food, feed, food-producing animal or substance that will be used for consumption, through all the stages of production, processing and distribution
- Traceability is a risk-management tool which allows food business operators or authorities to withdraw or recall products which have been identified as unsafe

EU General Food Law Regulation (178/2002, article 18)


Physical Changes
Caused by
-Freezing point temperatures
-Ice formation
Stop the metabolic process
Temperature
Caused by
-Excessive evaporation
-Drying-out (lose water content)
Keep high humidity, 85-95% is recomended
Humidity


Mechanical Damages
Produced by:
-Squashing
-Cracking
-Bruising
Speed up Microbiological Infestation and Biochemical changes
Depends on
Forces that influence the Cargo for long periods of time
Continuous vibrations
Vibration
High force shocks
Shock
Tilt of cargo and pallets
Tilt


Biochemical Changes
Ripening: Pre-climacteric, Climacteric, Post-climacteric (post harvest)
Start up the ripening process in other goods if they share the same storage area
Enzymatic Action: Food-stuff Contain enzymes which break down nutrients
Depend on temperature
Allelopaty: Gases released by fruits affect the metabolism of other goods in the cargo
Depend on ripeness of fruits, temperature, water contents, air composition
Respiration:
O2 is absorbed, CO2, water vapour and heat released
Ethylene
Humidity
Temperature
Carbon Dioxide
Oxygen

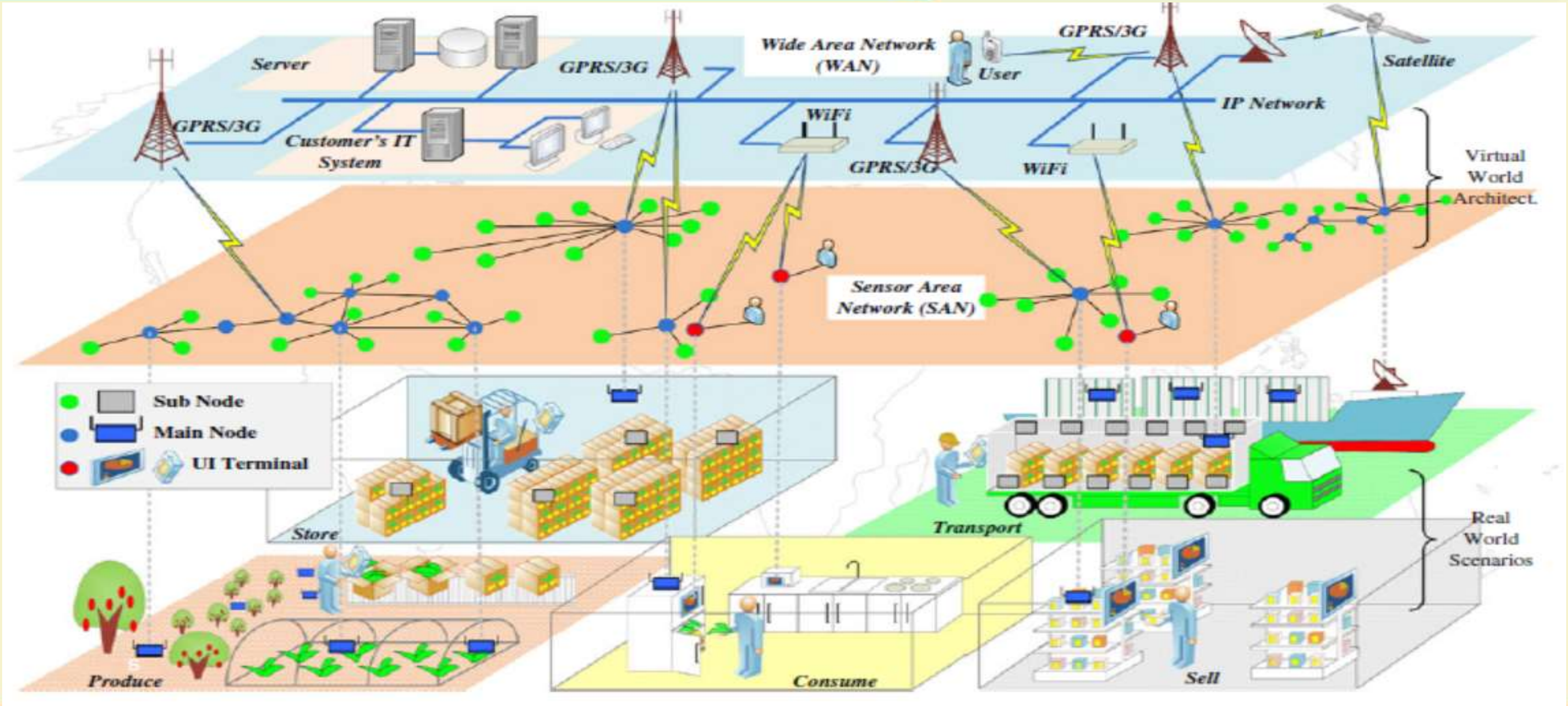


Aerobics
(molds)
Longer shelf life:
-Spores survive
Anaerobic
(rot pathogens)
None favourable environmental conditions
Oxygen
Microbiological Infestation
produced by:
-Fungal molds
-Yeast
-Bacteria
Temperature
Humidity
Favourable environmental conditions
produce
Microbiological Reproduction
Hydrogen Sulfide

No.	Target	Possible mechanisms
1	Location	-GPS (Global Positioning System)
		-Wireless cellular (GSM/3 G)
		-Short range wireless (WiFi, RFID or WSN)
		-Ultra wide band (UWB)
2	Temperature	-On-chip temperature sensitive transistor
		-Integrated semiconductor transducer
		-Temperature sensitive resistor
		-Thermal couple
		-Resistive Temperature Device (RTD)

3	Humidity	-Humidity sensitive capacitor
		-Humidity sensitive resistor
		-Integrated MEMS humidity transducer
4	CO2	-Infra red spectrum absorption detector
5	Oxygen	-Electrochemical (oxidation-reduction)
6	Ethylene	-Catalytic combustion of combustible gases
7	H2S	-Electrochemical (oxidation-reduction)
8	Soil Moisture	-Resistance measurement
		-Capacitance (dielectric constant)
		-Time domain reflectometer (TDR)

9	Vibration	-Mechanical vibration switch -Micro ball switch and counter -Integrated MEMS accelerometer
10	Shock	-Mechanical vibration switch -Micro ball switch and counter -Integrated MEMS accelerometer
11	Tilt	-Earth magnetic and gravity sensor -Integrated MEMS accelerometer
12	Light	-Ambient light sensing photo diode



Server
GPRS/3G
Wide Area Network (WAN)
User
GPRS/3G
Satellite
IP Network
GPRS/3G
Customer's IT System
WiFi
GPRS/3G
WiFi
Virtual World Architect.
Sensor Area Network (SAN)
Sub Node
Main Node
UI Terminal
Store
Transport
Real World Scenarios
Produce
Consume
Sell

Week 8: Lecture 5

BUSINESS ANALYTICS AND BIG DATA

We are going to learn

- What is business analytics
- Role of Bigdata

What is Analytics

Analytics is the use of data, information technology, statistical analysis, quantitative methods, and mathematical or computer-based models to help managers gain improved insight about their business operations and make better, fact-based decisions.

- Descriptive Analytics
  - Data visualization
  - Statistical description
- Predictive Analytics
  - forecasting, prediction, clustering
- Prescriptive Analytics
  - Optimization

Types of Questions and Analytics

	Descriptive	Predictive	Prescriptive
Questions	**What happened?** **What's happening?** **What actions are needed?** **What exactly is the problem?** **What actions are needed?**	**Why is this happening?** **What will happen next?** **Why will it happen?**	**What should I do?** **Why should I do it?** **What's the best that can happen?** **What if we try this?**
Enablers	• Ad hoc Reports • Dashboards • Data Warehousing • Alerts	• Data Mining • Text Mining • Web/Media Mining • Forecasting	• Optimization • Simulation • Decision Modeling • Randomized Testing
Outcomes	Well defined business problems and opportunities	Accurate projections of the future states and conditions	Best possible business decisions and transactions

Example: Retail Markdown Decisions

- Most department stores clear seasonal inventory by reducing prices.
- The question is:
  When to reduce the price and by how much?
  - **Descriptive analytics**: examine historical data for similar products (prices, units sold, advertising, …)
  - **Predictive analytics**: predict sales based on price
  - **Prescriptive analytics**: find the best sets of pricing and advertising to maximize sales revenue

Supply Chain Analytics

- Data management resources
  - Data acquisition & management (RFID, ERP, database)
  - Analysis (data mining)
- IT-based supply chain planning resources
- Performance management resources
  - Statistical process control, Six Sigma, etc.

Big Data Definition

- No single standard definition…

"***Big Data***" is data whose scale, diversity, and complexity require new architecture, techniques, algorithms, and analytics to manage it and extract value and hidden knowledge from it…

https://web.cs.wpi.edu/~cs525/s13-MYE/lectures/1/intro.pptx

Characteristics of Big Data:
1-Scale (Volume)

- **Data Volume**
  - 44x increase from 2009 2020
  - From 0.8 zettabytes to 35zb
- Data volume is increasing exponentially

Characteristics of Big Data:
2-Complexity (Varity)

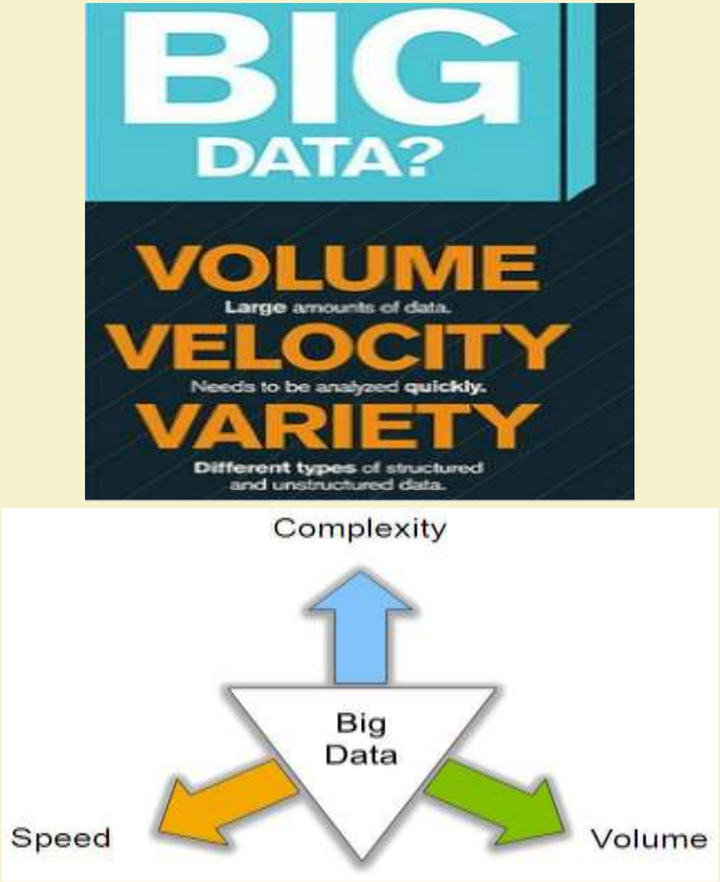
- Various formats, types, and structures
- Text, numerical, images, audio, video, sequences, time series, social media data, multi-dim arrays, etc…
- Static data vs. streaming data
- A single application can be generating/collecting many types of data

Characteristics of Big Data:

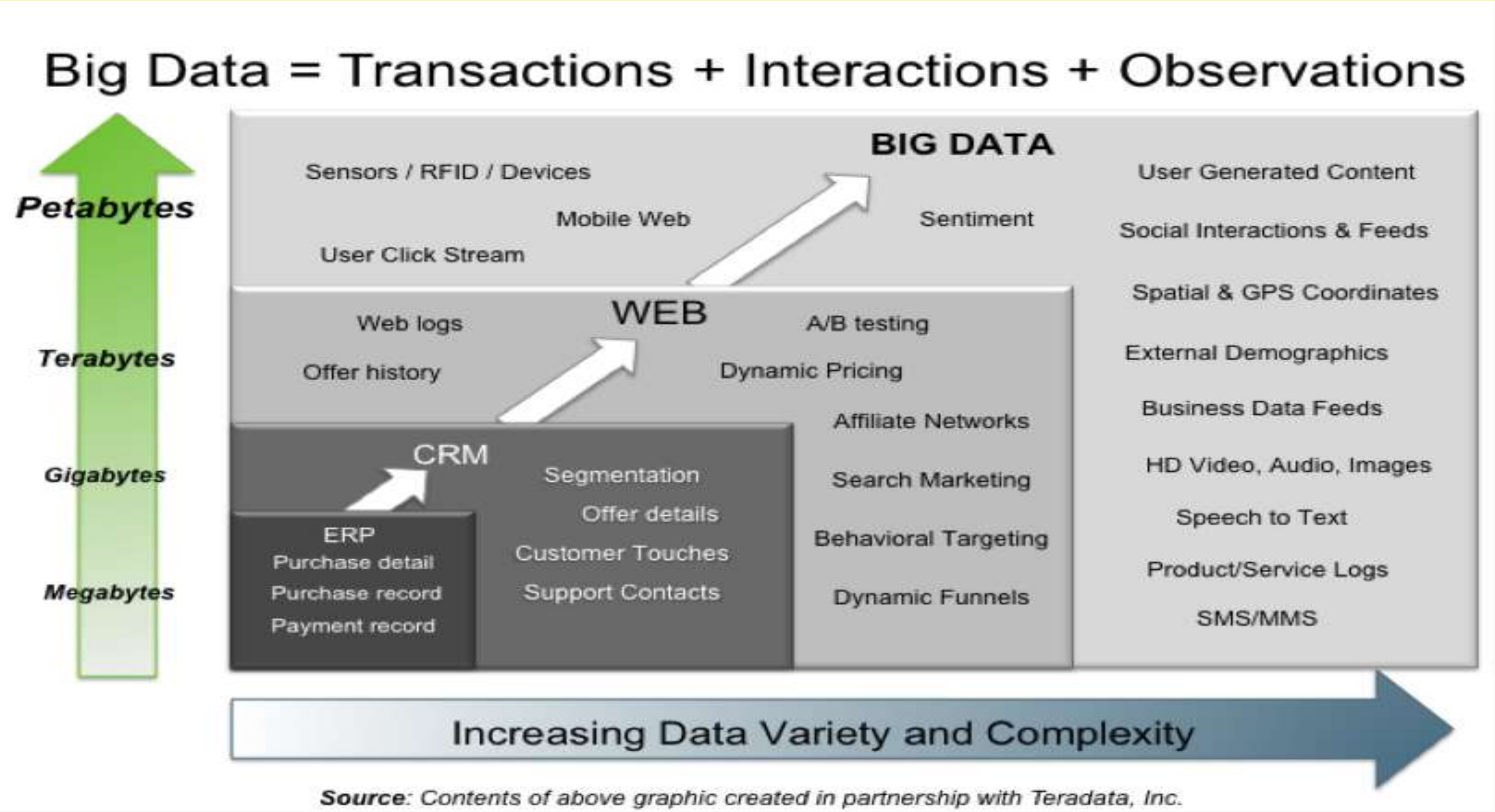
3-Speed (Velocity)

- Data is begin generated fast and need to be processed fast
- Online Data Analytics
- Late decisions → missing opportunities
- **Examples**
  - **E-Promotions:** Based on your current location, your purchase history, what you like → send promotions right now for store next to you
  - **Healthcare monitoring:** sensors monitoring your activities and body → any abnormal measurements require immediate reaction

Big Data: 3V's

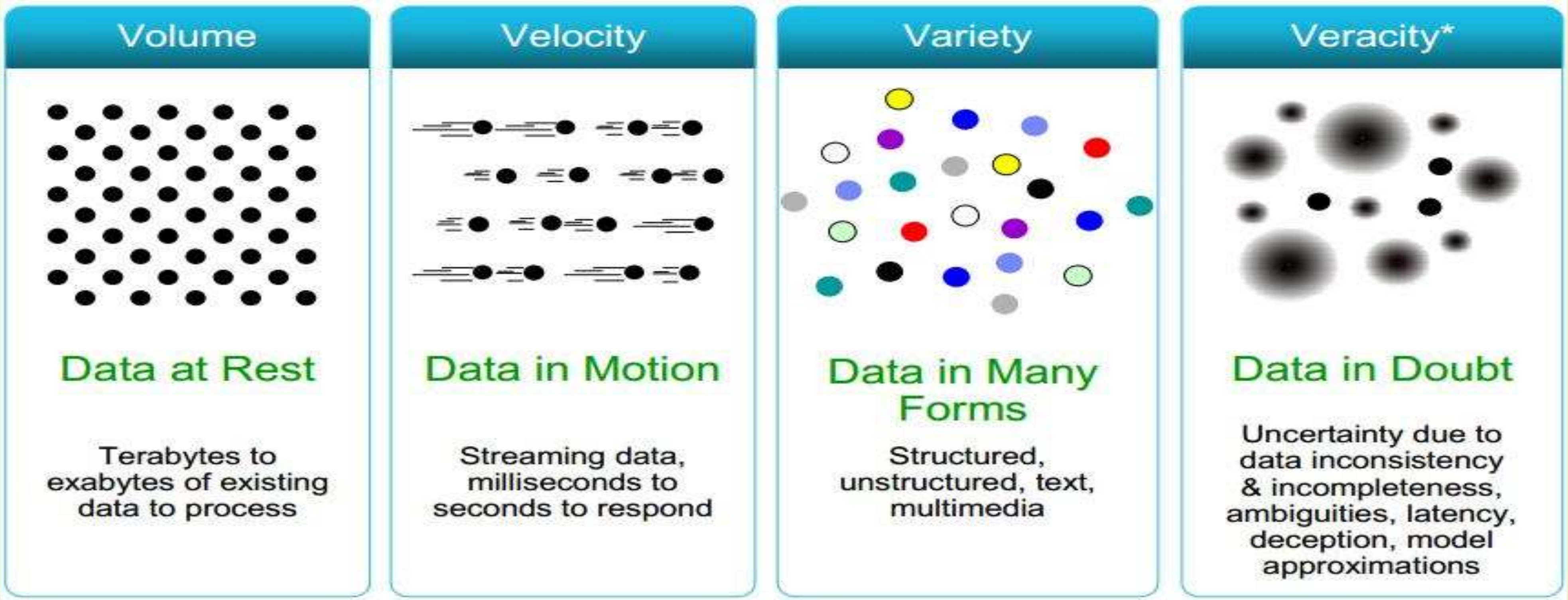


BIG
DATA?
VOLUME
Large amounts of data.
VELOCITY
Needs to be analyzed quickly.
VARIETY
Different types of structured and unstructured data.
Complexity
Big Data
Speed
Volume



Big Data = Transactions + Interactions + Observations
Petabytes
Terabytes
Gigabytes
Megabytes
BIG DATA
Sensors / RFID / Devices
Mobile Web
User Click Stream
Sentiment
User Generated Content
Social Interactions & Feeds
Spatial & GPS Coordinates
External Demographics
Business Data Feeds
HD Video, Audio, Images
Speech to Text
Product/Service Logs
SMS/MMS
WEB
Web logs
Offer history
A/B testing
Dynamic Pricing
Affiliate Networks
Search Marketing
Behavioral Targeting
Dynamic Funnels
CRM
Segmentation
Offer details
Customer Touches
Support Contacts
ERP
Purchase detail
Purchase record
Payment record
Increasing Data Variety and Complexity
Source: Contents of above graphic created in partnership with Teradata, Inc.

Some Make it 4V’s



Harnessing Big Data

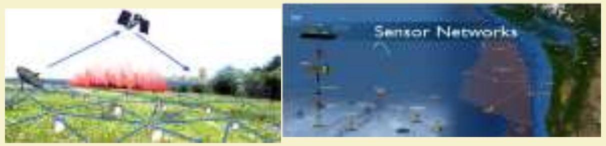
- **OLTP:** Online Transaction Processing (DBMSs)
- **OLAP:** Online Analytical Processing (Data Warehousing)
- **RTAP:** Real-Time Analytics Processing (Big Data Architecture & technology)

Who’s Generating Big Data

Social media and networks
(all of us are generating data)

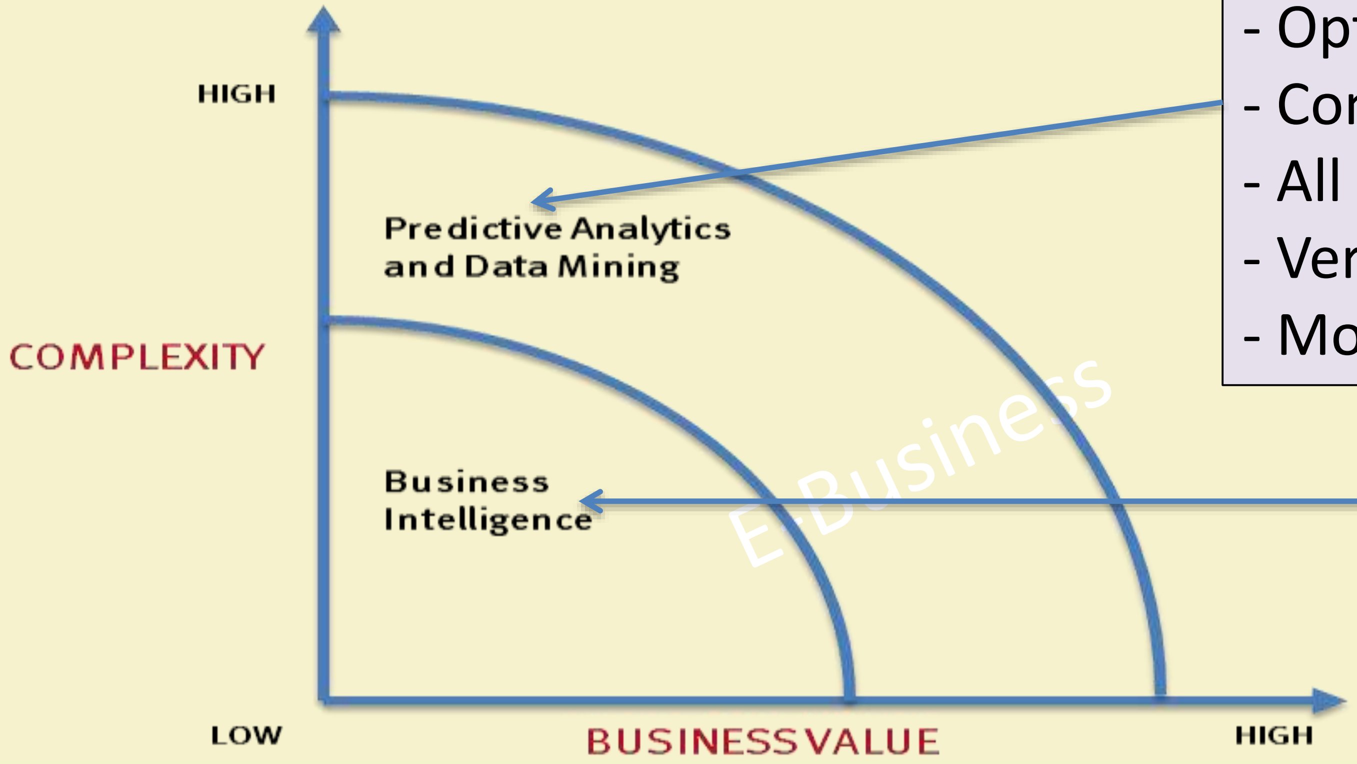
Scientific instruments
(collecting all sorts of data)

Mobile devices
(tracking all objects all the time)



Sensor technology and networks
(measuring all kinds of data)

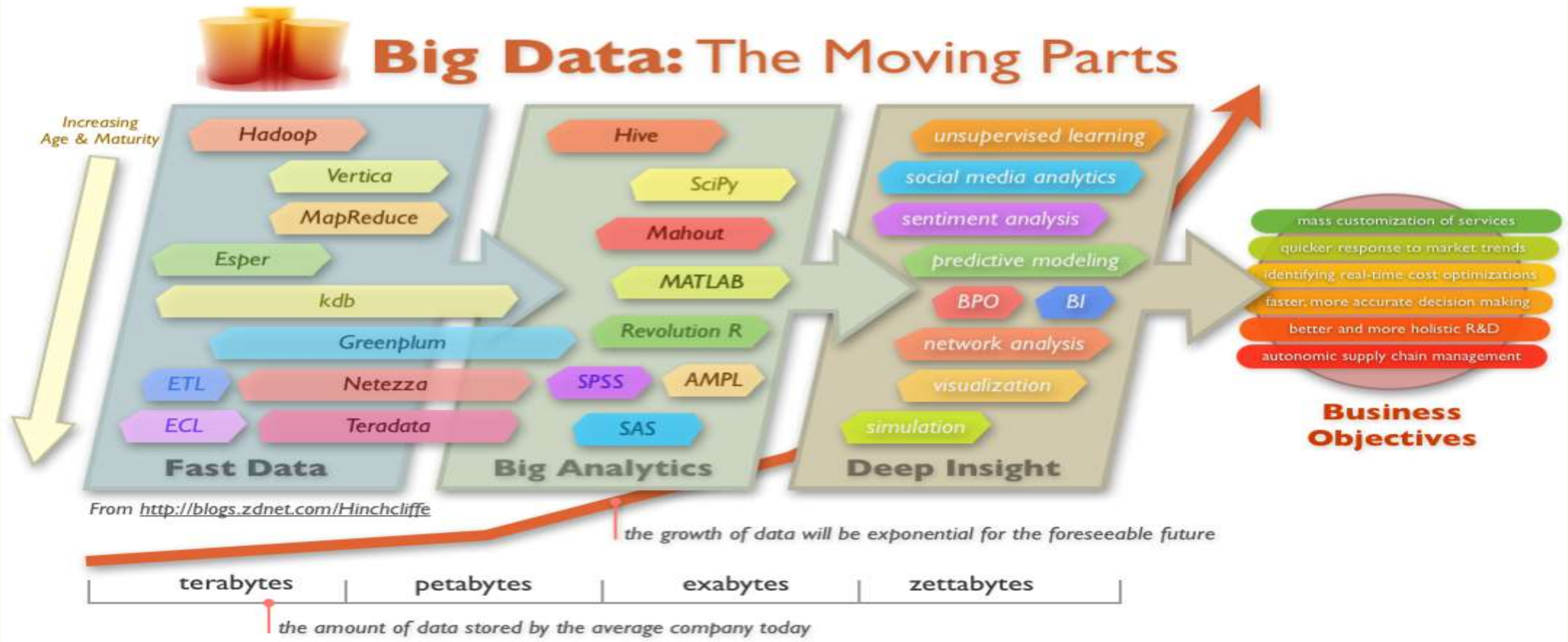
What's driving Big Data



- Optimizations and predictive analytics
- Complex statistical analysis
- All types of data, and many sources
- Very large datasets
- More of a real-time

- Ad-hoc querying and reporting
- Data mining techniques
- Structured data, typical sources
- Small to mid-size datasets

Big Data Technology



Supply Chains & Big Data

- Tracking
  - RFID/GPS
- Manufacturing
  - Cyber Physical Systems
- Sales and Marketing
  - Customer reviews, log

Example Supply Chain Big Data Sources

Data Type	Volume	Velocity	Variety
Sales	More detail – price, quantity, items, time of day, date, customer	From monthly & weekly to daily & hourly	Direct sales, Distributor sales, Internet sales, international sales, competitor sales
Consumer	More detail – items browsed & bought, frequency, dollar value, timing (RFM+)	From click through to card usage	Shopper identification, emotion detection, “Likes”, “Tweets”, product reviews
Inventory	Perpetual inventory by style, color, size	From monthly updates to hourly updates	Warehouse, store, Internet store, vendor inventories
Location/Time	Sensor data to detect location, better inventory control	Frequent updates within store and in transit	Not only where, but what is close, who moved it, path, future path, mobile device evidence

Waller & Fawcett (2013a) – *Journal of Business Logistics*

Big Data Opportunities to Improve:

- **Demand forecasting**
  - Link real-time sensors to machine-learning algorithms
    - Bar-coded checkout & Wal-Mart RFID chips already exist
  - Enables real-time response
- **Warehouse design & location**
  - System design for optimality
    - A classical operations research problem
    - Can use network analysis to be more complete
- **Supplier evaluation & selection**
  - Probably the most commonly researched supply chain function
  - Can consider more factors, more up-to-date data
- **Selection of transportation nodes**
  - Real-time truck/rail assignment
    - Already exists

Waller & Fawcett (2013) - *Journal of Business Logistics*

How Companies are using bigdata

Kyruus	Start-up	Data about physician networks – track patient leakage
Recorded Future	Start-up	Use Internet data to help predict
UPS	**Established**	**Track packages, monitor vehicles & route them**
United Healthcare	Established	Take voice calls, put in text, text-mine
Macys.com	Established	Personalization of ads
Bank of America	Established	Better understand customers by channel
Citigroup	Established	Monitor customer credit risk
Sears Holdings	Established	Real-time retail monitoring
Verizon Wireless	Established	Sell data on mobile phone user behavior (movement, buying)
Schneider International	**Established**	**Trucking – sensors for location, driver behavior**

Supply Chain Analytics with Bigdata

- Big data supports real-time decision making
  - Grocery stores
  - Wal-Mart
  - American Airlines – yield management
  - Trucking – monitor real-time breakdown response