



SREENIVASA INSTITUTE OF TECHNOLOGY AND MANAGEMENT STUDIES.
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MCA DEPARTMENT
LECTURE NOTES
INTERNET OF THINGS

UNIT-IV

INTEGRATED BILLING SOLUTIONS IN THE INTERNET OF THINGS

"The value of the Internet of Things lies not in connecting things, but in extracting intelligence from the data they generate."

– Samuel Greengard

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Unit IV

Cost of RFID and the Internet of Things, Benefits of RFID and the Internet of things, Cost Benefit sharing, A technical framework for Integrating Billing Capabilities into the EPC global Network-Business Models for the Internet of Things-Business Models and Business Model Innovation-Value creation in the Internet of Things-

Exemplary Business Model Scenarios for the Internet of Things.

Unit Overview

This unit introduces the economic, technical, and business aspects of RFID and the Internet of Things (IoT). It explains the costs involved in implementing RFID and IoT solutions, the benefits achieved through automation and real-time data collection, and methods for sharing costs and benefits among stakeholders. The unit also discusses the integration of billing capabilities into the EPCglobal Network, various IoT business models, business model innovation, value creation strategies, and real-world IoT business model scenarios across different industries.

Objectives of the Unit

1. To understand the cost components involved in RFID and IoT implementation.
2. To analyze the operational and economic benefits of RFID and IoT technologies.
3. To explain cost-benefit sharing mechanisms among stakeholders in IoT ecosystems.
4. To study the technical framework for integrating billing capabilities into the EPCglobal Network.
5. To understand different IoT business models and their characteristics.
6. To examine the concept of business model innovation in IoT.
7. To analyze value creation strategies enabled by IoT technologies.
8. To explore exemplary IoT business model scenarios across various application domains.

Learning Outcomes

After completing this unit, students will be able to:

1. Describe the costs associated with RFID and IoT deployment.
2. Explain the economic and operational benefits of RFID and IoT systems.
3. Evaluate cost-benefit sharing approaches among IoT stakeholders.
4. Discuss the technical framework for billing integration within the EPCglobal Network.
5. Compare different IoT business models and their applications.
6. Analyze innovative business models that leverage IoT technologies.
7. Explain how IoT creates value for businesses and customers.
8. Apply IoT business model concepts to real-world industrial scenarios.

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Importance of Studying this Unit

- Provides an understanding of the financial feasibility of RFID and IoT projects.
- Helps organizations evaluate return on investment (ROI) before implementation.
- Enables informed decision-making regarding IoT investments and deployment strategies.
- Explains how IoT creates new revenue streams and business opportunities.
- Introduces innovative business models for digital transformation.
- Demonstrates the role of billing systems in supporting IoT services.
- Prepares students to design sustainable and profitable IoT-based solutions.
- Enhances knowledge of value creation in smart industries and connected ecosystems.

Key Concepts

- RFID Implementation Cost
- Internet of Things (IoT) Cost Structure
- Hardware, Software and Infrastructure Costs
- Deployment and Maintenance Cost
- Benefits of RFID
- Benefits of IoT
- Operational Efficiency
- Cost-Benefit Analysis
- Cost-Benefit Sharing
- Return on Investment (ROI)
- EPCglobal Network
- Electronic Product Code (EPC)
- Billing Capability Integration
- Technical Billing Framework
- IoT Business Models
- Subscription-Based Business Model
- Pay-per-Use Business Model
- Product-as-a-Service (PaaS)
- Outcome-Based Business Model
- Data-Driven Business Model
- Business Model Innovation
- Digital Transformation
- Value Creation in IoT
- Customer Value Proposition
- Revenue Generation
- Smart Supply Chain
- Smart Manufacturing
- Smart Healthcare
- Smart Agriculture
- Smart Cities
- Predictive Maintenance
- Asset Tracking
- Connected Services
- IoT Ecosystem



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INTRODUCTION

The Internet of Things is one of the most promising technological developments in information technology. It promises huge financial and nonfinancial benefits across supply chains, in product life cycle and customer relationship applications as well as in smart environments. However, the adoption process of the Internet of Things has been slower than expected. One of the main reasons for this is the missing profitability for each individual stakeholder. Costs and benefits are not equally distributed. Cost benefit sharing models have been proposed to overcome this problem and to enable new areas of application. However, these cost benefit sharing approaches are complex, time consuming, and have failed to achieve broad usage.

While RFID and other Auto-ID technologies continue to be major components of the Internet of Things, there are other technologies, such as sensors, actuators, and networked infrastructures that will further add to the ongoing cost discussion.

The major hurdles in the process of deploying the Internet of Things are

- Cost for hardware & Software,
- Integration,
- Maintenance,
- Business process reengineering
- Data analysis.

Some Internet of Things related applications may never come true, because some of the stakeholders would need to spend more on technology and integration than can be justified by internal benefits. There are several problematic aspects in cost benefit analysis and sharing:

- Detailed cost benefit analysis can be time consuming
- It is difficult to identify, measure and analyze all costs and benefits associated with an Internet of Things
- Companies are reluctant to share benefits

Cost benefit sharing models do not scale, as they are subject to bi-directional negotiations. An alternative solution to cost benefit sharing could be based on selling and buying information that is provided through the Internet of Things. For this, a billing solution is needed to price and bill information. Similar concepts are known from the telecommunications industry, where billing solutions are an integral part of the overall infrastructure, allowing billing of different services, such as

- Voice calls,
- SMS,
- Internet access and

- Premium services

across service providers and different countries.

Basic of RFID

- RFID –Radio Frequency Identification
- RFID is a form of wireless communication that uses radio waves to identify and track objects.
- RFID uses electromagnetic fields to automatically identify and track tags attached to objects.
- RFID can also be used to track animals and birds by attaching tags to them.

Components & Working of RFID

▪ Basic components of the RFID system

- RFID Tag, Antenna, RFID Reader, Software



- | | |
|---|---|
| <ul style="list-style-type: none">❖ RFID Tag is attached to assets.❖ It consists of a Microchip and antenna within it.❖ It stores information about the object being tagged to it.❖ It is a transponder, It receives radio signals and gives a response to the radio signals.❖ It has a small memory within the chip.❖ Passive Tags don't need a battery {short range, low data rate, low efficiency} and Active Tags are expensive with a battery in it {Long range, high data rate, high efficiency}.❖ RFID Tags and RFID Readers have antennas within it. | <ul style="list-style-type: none">❖ RFID Reader is used to activate the tags.❖ It collects the data from the RFID Tags.❖ RFID Readers have scanning antennas.❖ Fixed Readers are mounted to specific locations and they track objects without human intervention.❖ Mobile Readers are hand-held and usage is flexible.❖ Software runs on different systems which collects the data at the final system for controlling and monitoring purposes. |
|---|---|



Applications of RFID

- People Tracking {Hospital}
- Animal Tracking
- Security {Jewellery}
- Library {Books Tracking}
- Inventory Management {Monitoring, Controlling, Storing, Production etc.}
- Document Tracking
- Defence {Weapon Movement, Soldier's Movement}



Cost of RFID and the Internet of Things

There are numerous costs associated with the adoption of the Internet of Things. While the Internet of Things is not synonymous with RFID, results from cost analysis for RFID can be used as a basis for further calculations. Agarwal (2001) lists six different costs of RFID deployment for manufacturing firms

- The cost of the tag itself,
- Cost of applying tags to products,
- Cost of purchasing and installing tag readers in factories and/or warehouses,
- Systems integration costs,
- Cost of training and reorganization,
- Cost of implementing application solutions.

Feinbier et al. (2008) list relevant costs for RFID installation in detail, based on experiences in the steel industry. On the basis of both approaches, similar cost structures can be inferred for the Internet of Things



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Cost level	Cost of tagging (Agarwal 2001)	Cost considerations for RFID (Feinbier et al. 2008)	Cost of Internet of Things adoption
1 Mobile devices	• Cost of the tag itself • Cost of applying tags to products	• Tags	• Cost of mobile technologies, such as data carriers (e.g., tags), sensors, actuators or smart devices • Cost of applying mobile technologies to things
2 Aggregation devices and software	• Cost of purchasing and installing tag readers in factories and/or warehouses	• Readers • Antenna and cabling • Installation • Tuning • Controllers • Software platform (middleware)	• Cost of purchasing edge devices (e.g., readers, gateways, controllers, accessories) and edge ware for fixed and/or mobile environments • Installation and technical optimization costs
3 Integration	• Systems integration costs	• (to legacy systems)	• Systems integration costs including new interfaces as well as necessary updates, extensions, or replacement of existing systems
4 Training and reorganization	• Cost of training and reorganization	• Process (incl. redesign and human elements)	• Training cost • Reorganization / business reengineering / business model innovation
5 Application	• Cost of implementing application solutions		• Cost of implementing internal application solutions beyond existing applications
6 Networking (technical and organizational)			• Cost for networking in an open environment, including e.g., improved security, fine layered access control, multi-directional communication, product data contracts, service level agreements,



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			standardized syntax and semantics, data conversion, synchronization, trust concepts
7 Operational		• Maintenance	• Cost for maintenance • Other operational costs for running (e.g., data storage and analysis), extending and improving the system

Benefits of RFID and the Internet of Things

Baars et al. (2008) have identified four different approaches towards systemization of RFID benefits

➤ **Collecting and grouping –**

Benefits are collected and grouped.

➤ **Layer of impact**

Benefits are structured to impact layers such as short term and long term automation, informational and transformational benefits, proven or potential.

➤ **Locus of impact**

These studies highlight who benefits, thus it automatically considers benefits to multiple stakeholders.

➤ **Indicator system**

Established evaluation systems, such as Balanced Score cards are used to structure RFID benefits. Collective benefits can be achieved by all of these stakeholders. These include:

- **Reduced product shrinkage:** reduction of loss of goods through misplacement, spoilage, and theft
- **Improved information sharing:** product related data may be exchanged to benefit multiple stakeholders, problems resulting from converting paper-based information to digital information are avoided and manual data-entry is drastically reduced
- **Compensatory benefits:** benefits provided through other stakeholders, including for example cost benefit sharing, funded research, bonus payments, vouchers, information (e.g. sales data)

Companies in general may benefit from:

- **Increased inventory, shipping and data accuracy:** e.g., differences between **real stock** numbers and assumed stock, based **on false data**
- **Subsequent fault reduction: inaccurate and incomplete visibility** may lead to false decisions and can be avoided through the Internet of Things



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- **Faster exception management (agility):** capability of responding to unplanned events in a timely manner before critical problems escalate
- **Asset management:** better asset utilization may lead to an opportunity to reduce asset inventory, reduced asset shrinkage, better shipment consolidation, reduced energy consumption and improved reverse logistics.
- **Product rotation:** methods of inventory control, such as First In, First Out (FIFO) can be used more accurately to ensure efficient stock rotation e.g. in time sales for perishable goods.

Manufacturers and suppliers benefit mainly from:

- **Production tracking:** tracking of raw material, work-in-progress inventory, assembly status tracking and finished products
- **Quality control:** ensured quality control in production
- **Supply / production continuity:** enabled through improved material tracking
- **Compliance:** e.g., in case of mandates issued for example by large retailers or legislators and regulators

Distributor and logistics provider as well as internal distribution and logistics departments benefit from:

Material handling: time (labor) savings for loading / unloading of trucks, administrative overhead at the goods receipt , cross-docking , customs clearance delivery lead times and reduced delays, faster inventory, goods receiving, loading and unloading as well as reduced human errors through Auto-ID

Space utilization: achieved through reduced buffers and reduction of product storage incompatibilities (e.g., placement of hazardous goods), based on better data accuracy through RFID usage

Retailer benefits include: based on better data accuracy through RFID usage

- **Customer service:** RFID can be used to simplify checkouts and payments as well as for promotion management
- **Lower inventory:** reduced stockouts and smaller buffer stocks, due to improved inventory data
- **Reduced stockouts:** substantially reduced stockouts can be achieved through RFID if movements to the shop floor can be tracked
- **Promotion execution:** RFID and the Internet of Things may be used to obtain better visibility for timely placements of promotional items
- **After sales services:** in after-sales service, RFID may be used for warranty issues,



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repair and goods authentication.

Benefits for consumers are:

- **Personal access to product specific information:** e.g., to be able to access the product history of a car, based on a vehicle identification number
- **Active participation opportunity:** e.g., through beta testing, product ratings, field reports, applications and more
- **Interaction with other stakeholders:** e.g., automatic updates and repairs, dynamic safety warnings, product recalls, public applications
- **Home automation and leisure applications:** e.g., room monitoring, smart devices, intelligent toys

Benefits to society include:

- **Consumer protection / safety:** e.g., food and health safety, environmental monitoring
- **Security:** e.g., to avoid terrorist attacks, customs support
 - **Trade facilitation:** comparable with the introduction of Infrastructure optimization: e.g., roads, public transportation

Cost Benefit Sharing

Costs and benefits of the Internet of Things that are not evenly distributed between the stakeholders.

- Cost benefit sharing models may be used as a tool to balance these asymmetries.
- Cost benefit sharing in combination with RFID has been researched by several authors.
- Sharing benefits and investments in multi-tiered situations is seen as a core requirement for wide-scale deployment of RFID.
- Hirthammer and Riha (2005) define cost benefit sharing as:

“A systematic and system-oriented incentive system that motivates companies in a network to participate in joint projects that do not benefit them directly. A Joint Project is a cooperative effort to improve the processes or resource allocation in the network. It involves at least two parties in the network.”

According to Hirthammer and Riha (2005), the cost benefit sharing process loop can be structured in several subtasks:

1. Detailed process analysis in the network through auditing
2. Enquiry of weak points through benchmarking
3. Development of corresponding actions to solve or lessen the effect of the weak points based on overall strategies and goals



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4. Cost benefit sharing
 - a. Calculation of costs
 - b. Evaluation of benefits
 - Calculate monetary benefits
 - Calculate qualitative benefits
 - Evaluate total benefit
 - Calculate share of benefit
5. Implementation of actions proposed in step 3
6. Controlling
7. Feedback loop to adjust the system to external dynamics

A Technical Framework for Integrating Billing Capabilities into the EPCglobal Network

The well-known Fosstrak EPCIS software has been integrated with jBilling, an open source billing solution that is mainly being used in telecommunication companies. The jBilling system has been chosen for the following three reasons.

- Firstly, it does not require an upfront investment in software.
- Secondly, it is open source and, therefore, allows modification to the software.
- And thirdly, it aligns well with the technologies used in Fosstrak and therefore may allow a tighter integration

Both products use Tomcat as Web-server, but there are two different relational databases in use, Hypersonic for jBilling and MySQL for Fosstrak. jBilling can run on MySQL, so that Hypersonic could be eliminated in a further integration effort. To combine the two different systems, there are two initial requirements:

1. There should be an integrated login procedure .
2. Selected EPCIS events should be translated to jBilling purchase orders

The accounting process may be triggered by an event, such as a pallet with an RFID tag passing a dock-door (1a, 1b). Other billing activities may be started through a query for payable information (2). As part of the Fosstrak authentication process (3a), the access rights, including the availability of a billing account (3c), are checked via the jBilling Application Programming Interface (API).

For this purpose, a combined login process has been implemented as an option in the Fosstrak EPCIS query interface (NextFigure) at the LogDynamics Lab.

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- For this purpose, a combined login process has been implemented as an option in the Fosstrak EPCIS query Interface.



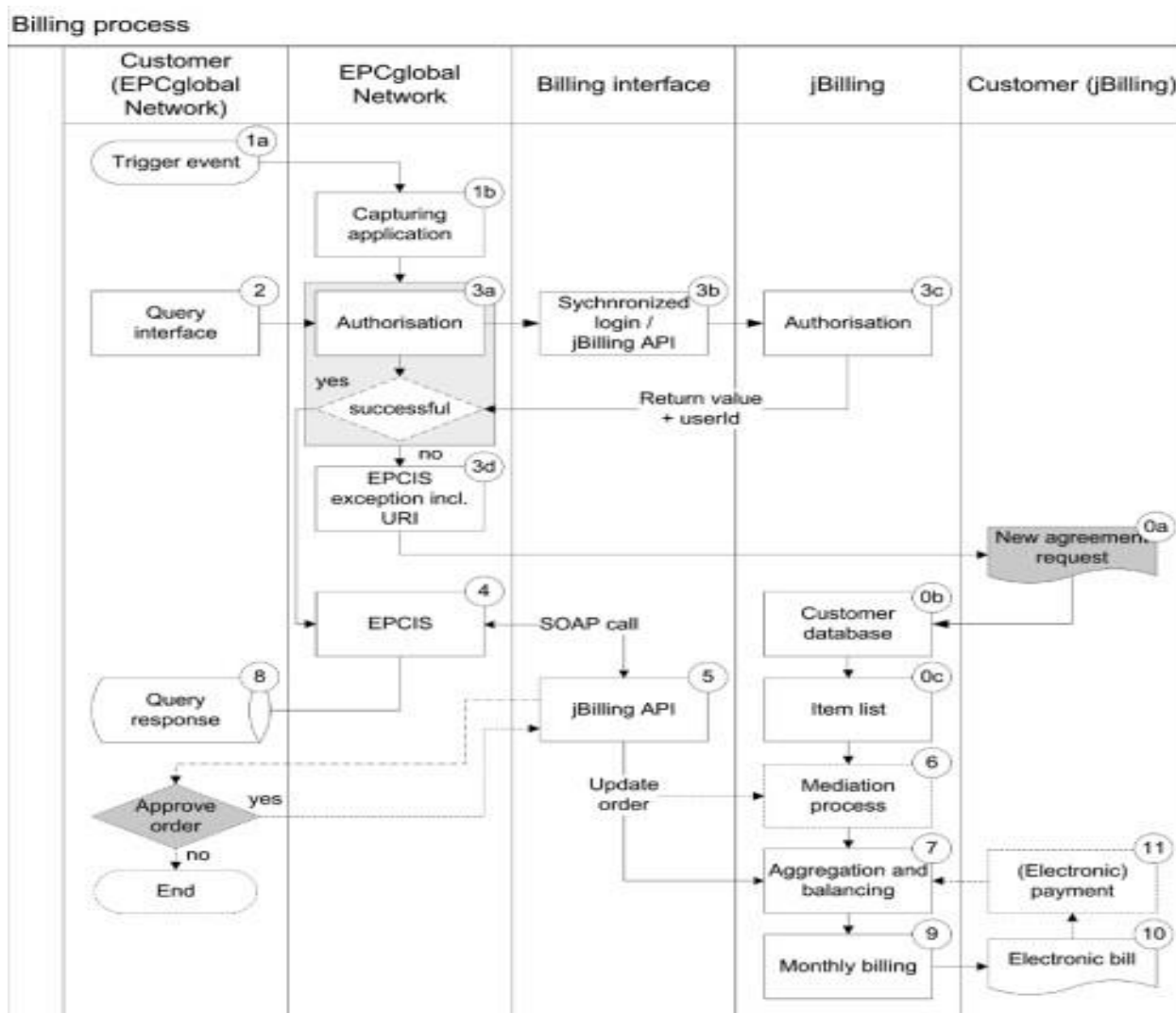
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- If the input data is null or missing, jBilling generates an API exception (jBilling 2010).
- Otherwise jBilling returns different integer values as described below.
- 0 -The user was successfully authenticated and his current status allows him entrance to the system.
- 1 -Invalid credentials. The user name or password are not correct.
- 2 -Locked account: The user name or password are incorrect, and this is the last allowed login attempt. From now on, the account is locked.
- 3 -Password expired: The credentials are valid, but the password is expired. The user needs to change it before logging in
- If no valid contract in jBilling can be found, JbillingAPIException could be converted into an EPCIS exception, containing a Uniform Resource Identifier (URI) that links to a new agreement request (3d).
- The agreement may contain pricing information, financial details, such as preferred payment service, and payment options (e.g. monthly). b
- For further usage in the Internet of Things it would be favorable, if individual service level agreements and information quality details could be included or linked as well.
- The agreement is stored within the jBilling customer database (0b) and will be used for calculating customer-specific prices later on.
- In a further effort it would be possible to create, update and delete new jBilling users from within the EPCIS, using the jBilling API.
- Consequently, users would not need to deal with two different systems.
- After successful authorisation, the EPCIS queries are processed.
- The EPCIS will make a SOAP call to the jBilling API (5).
- The userID provided during the authorisation process is used to link an order to a jBilling account.
- The createOrder and updateOrder methods are used to transfer events into corresponding orders.
- Optionally, a mediation process (6) can be called to enable dynamic pricing, based on business rules.
- If prices per item are predefined in jBilling and if no changes are required, the mediation process does not need to be called (jBilling 2010).
- The jBilling API updates the account balance (7). Optionally, an approval request for the end-user can be implemented.
- Finally the query response is delivered and the account balance is updated by jBilling.
- Usually, monthly billing will be used to invoice the aggregated values in business scenarios (9).
- In order to avoid problems resulting from analogue to digital media conversions and cost intensive manual labor, electronic bills (10) and electronic payment (11) will be preferred.



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- Additionally, an invoice is sent via e-mail or traditional postal services to a defined recipient.



Business Models for the Internet of Things

The Internet has significantly changed the way products and services are marketed and distributed and thus led to a series of new types of business models. Current applications in the Internet of Things generally focus on the optimization of existing processes and associated cost reductions within companies and along value chains. Product Life Cycle Management, Customer Relationship Management, and Supply Chain Management are typical application scenarios.

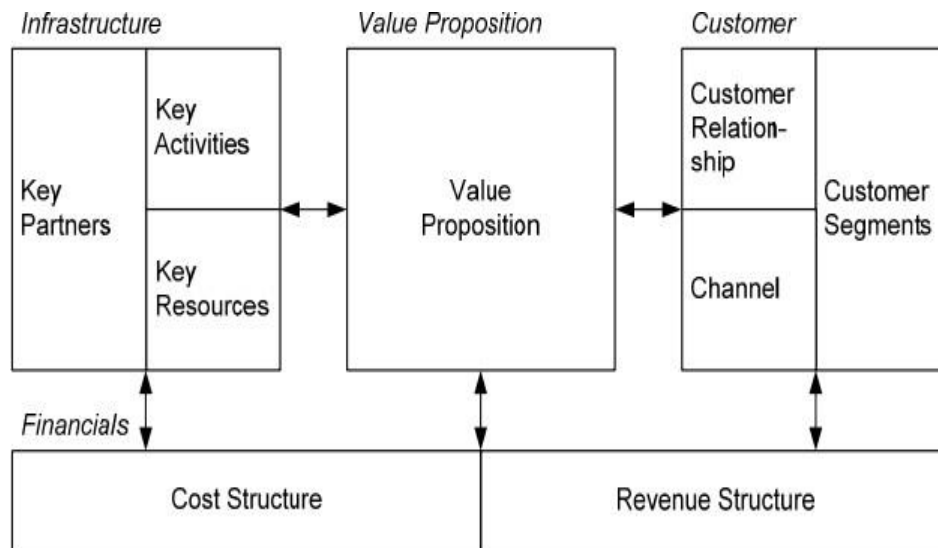
New application scenarios, sometimes referred to as smart technologies and smart services, are more focused on revenue generation. The business model has to be seen as the replacement



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or complement of the traditional unit of analysis, as a result of the altered surrounding conditions. Today's business condition is determined by technological progress, service orientation, the digitalization of products as well as increasing relevance of cooperation and ecosystems of different companies, which blur the boundaries of the individual enterprise. Accordingly, each business is implicitly based on a business model, even though it is not always explicitly presented. Timmers (1998) defines a business model as “an architecture of the products, services and information flows”. This includes the involved actors and roles as well as the potential value created for all participants and the source of revenue.

In relation to the Internet of Things we see the business model as a major element to unite its technical developments with its economical business perspective. According to Afuah and Tucci (2000), “a business model can be conceptualized as a system that is made up of components, linkages between the components, and dynamics”. Components refer to the elements to be addressed by a business model. Just like the definitions of the term “business model” the proposed components vary largely between different authors. Osterwalder and Pigneur (2009), defined a framework which is referred to as the “**business model canvas**”. The applicability of the model is proven by its use in practice



The business model framework depicted in Figure includes four main perspectives of the business model, namely

- The value proposition,



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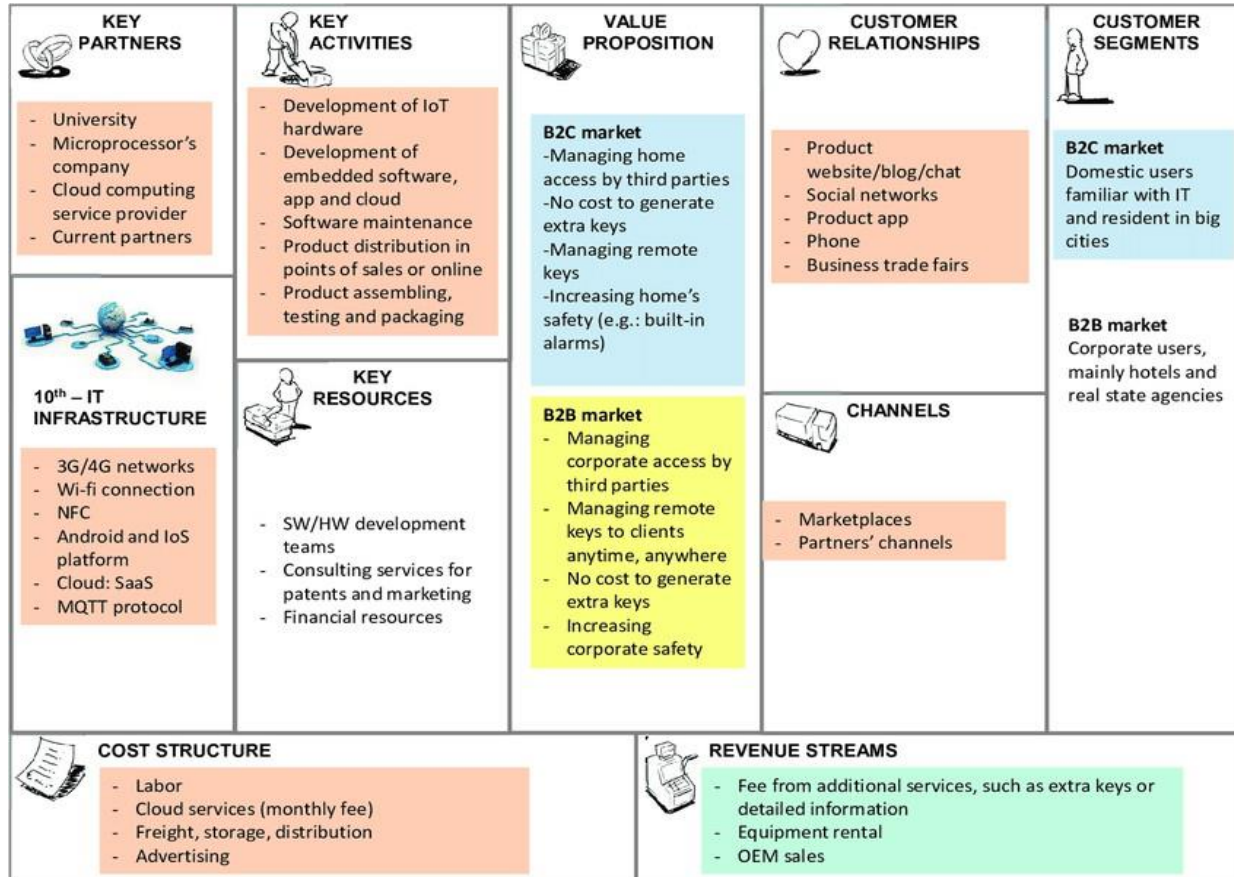
- The customer,
- Financials
- The infrastructure.

The components are not stand-alone but mutually influence each other. The value proposition specifies what is actually delivered to the customer. This goes beyond the product or service offered. It describes which customer needs are satisfied and details what other quantitative (e.g., price or speed of service) and qualitative aspects (e.g., brand, design, cost/risk reduction) contribute to the offered value. In the Internet of Things we consider raw data about physical objects as well as any aggregated or processed information a core component of the value proposition. The customer perspective includes the customer segments addressed by the company, such as related channels and customer relationships.

- The **customer segments** define the different groups of people that are served. Different types of customer segments can be distinguished: mass market vs. niche market, segmented vs. diversified or multisided platforms. Multisided platforms will exist, if two or more interdependent customer segments are served by the company (e.g. credit card companies). The company can reach its customers, respectively customer segments through different channels. These can be direct or indirect and owned by the company itself or by partners.
- **Channels** can be aligned to the different phases of the lifecycle, such as creating awareness for the value proposition, evaluation of the value proposition through the customer, purchase, delivery and after sales.
- **Customer relationships** are often determined by the channels used. Relationships can range from very loose (self-service, automated services) to highly engaged (personal assistance, communities, co-creation). The financial perspective comprises the costs as well as the revenues.
- The **revenue structure** depicts the sources and ways of revenue generation. Here, different types of revenue streams can be distinguished: asset sale, usage fee, subscription fee, lending / renting / leasing, licensing, brokerage fee, and advertising.
- The **cost structure** describes the most important costs (variable and fixed) inherent to the business model. The business model can be rather value or cost driven. Companies can use economies of scale or economies of scope to create a successful business model. Key partners, key activities and key resources can be referred to as the infrastructure components.
- The **key resources** are the assets required to make the business model work. Key resources can be physical, intellectual, human or financial.

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- The **key activities** describe the most important actions to be performed by the company in order to create, offer and market the value proposition. These can be producing, problem solving or developing and maintaining a platform, respectively.
- **Key partners** are the network of suppliers and collaboration partners (strategic alliances, outsourcing partners, co-creation) the business model depends on.



Business Model Innovation

Business model innovation is the art of enhancing advantage and value creation by making simultaneous—and mutually supportive—changes both to an organization's value proposition to customers and to its underlying operating model. External factors, such as technological innovations, increased competition, and market changes as well as legal or regulatory changes are seen as the dominant triggers of business model innovation. Business model innovation can help to align innovation activities within the company. Business model innovation as a process resulting in a qualitatively new business model, which differs distinctively from the previous. A deliberate change of one or more key elements of the



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business model, respectively their interrelations, has to take place. Some of the most successful companies that have used a distinctively new business approach based on the Internet are shown in Table

Company	Traditional business	Initial business model innovation	Further developments
Amazon	Book trade	Online shopping Automated distribution model Collaborative filtering	Shopping portal Digitalisation (mp3, books), Terminals (Kindle), Mobile payments Amazon web services (incl. billing)
eBay	Classifieds Flea markets Auctions	Online auctions	Shopping portal Payment services (PayPal)
Google	Yellow pages	Hypertext web search Prioritized advertisements	Terminals (Android), Video (You Tube), Maps (Google Maps), Web based software (e.g. Google Docs), Digitalized books Payment services (Checkout)
Apple iTunes	Music shops	Music digitalization Terminals (iPod, iPhone, iPad) Applications (apps)	Videos, Newspapers

Value Creation in the Internet of Things

A typical business transaction today is defined by a physical product, information stream, and money stream. The Internet of Things may be seen as an approach to align these different streams. It provides a higher level of visibility and control mechanisms. Moreover, in the Internet of Things, information itself may become a major source for value creation and thus the value proposition. This includes information only made possible through Internet of Things technologies as well as the association of existing information to physical products. Traditionally, the money stream is exclusively dependent on the product stream prices.



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A separate price for the information is not defined. Instead, information is most often expected to be free of charge. It is obvious that the costs of information are hidden in the product price. However, the reluctance to pay for information may change over time. In B2C-markets, the willingness to pay for digital goods has increased to 88%. Even though digital goods (e.g. software, tickets, travel, songs, and videos) and information are not synonymous, it is still obvious that there is a change in society to accept the Internet as a business transaction platform. In addition to direct information payments, alternative revenue streams should be considered.

Laws of Information

Even though information is recognized as an asset on its own right, quantitative measurements are difficult to achieve. It consumes a growing number of organizational resources for data capturing, storage, processing and maintenance. While hardware and sometimes software may be capitalized, the value of information in general is not financially recognized in the balance sheets. Information may be considered a product that is produced out of raw data through hard- and software utilization. Moody and Walsh (2002) define seven “laws of information”, explaining the specifics of information compared to other (physical) assets. These “laws of information” provide opportunities for new business and pricing models for the Internet of Things:

- **First Law of Information:** Information is (Infinitely) Shareable and Can Be Shared with Others Without a Loss of Value
- **Second Law of Information:** The Value of Information Increases with Use and It Does Not Provide Any Value, If It Is Not Used at All
- **Third Law of Information:** Information Is Perishable and It Depreciates Over Time
- **Fourth Law of Information:** The Value of Information Increases with Accuracy.
- **Fifth Law of Information:** The Value of Information Increases When Combined with Other Information
- **Sixth Law of Information:** More Information Is Not Necessarily Better .
- **Seventh Law of Information:** Information Is Not Depletable

Revenue Generation in the Internet of Things

Information may become the main source of value creation and thus a major part of the value proposition in the Internet of Things. Information can be directly associated to things or products and instances of products. The usage, status, and location of things become traceable. This allows for new value proposition scenarios, such as the provision of

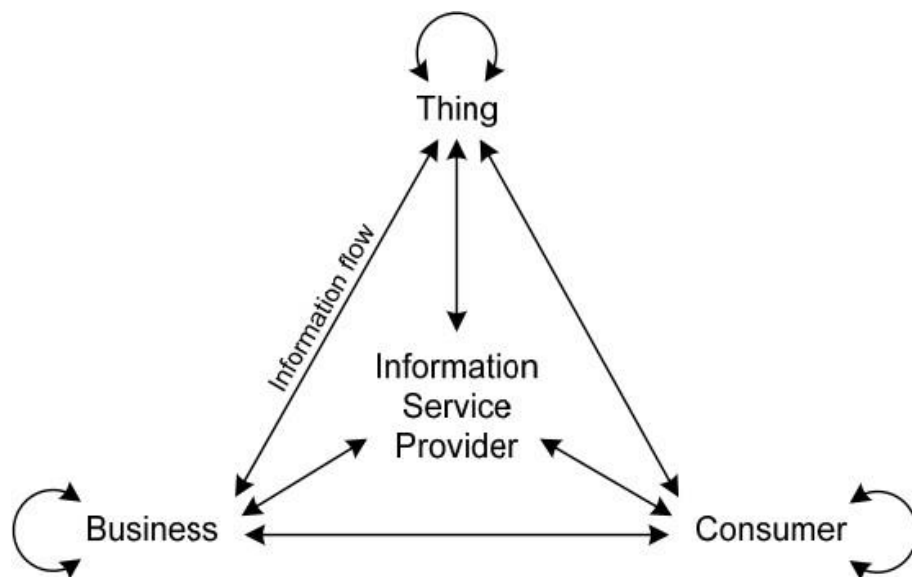


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additional product-related data to or the exact billing of products or services based on the actual use (e.g., rental car, returnable transport items). The following requirements constitute the specifics for the value proposition:

- **Providing the right information ...** – Linked through a unique identifier to a physical product
- **... in the right granularity ...** – High information granularity, providing a new dimension of clarity and insight
- **... and the right condition ...** – High information accuracy – Aggregation of information from various sources, such as tags, sensors or embedded systems – Correlation, integration, and further analysis of information in a way that allows new insights to be derived – Defined syntax and semantics
- **... at the right time ...** – Timeliness of information – Access to real time information as well as to historical data for business analysis – Real-time analytics and business intelligence for high resolution management – Intelligent real-time decision-making capability based on real-time physical events.
- **... anywhere in the network ...** – Online access and possibly offline usage – Mobile access
- **... at an appropriate price.** – Price transparency – Low premium for billing service, the price should be paid for the information rather than the infrastructure

In order to fully understand the information exchange on the Internet of Things the information flows and actors involved have to be considered. Figure depicts information providers in the Internet of Things and information flows between them.





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They can be depicted as a triangle of information exchange. Information flows can be direct, such as for example thing-to-thing, business-to-consumer or consumer-to-thing, or indirect, such as from thing-to business through an information provider or from business-to-business through a thing. Things include products that communicate their ID and status through sensors as well as data processing units and actuators.

Exemplary Business Model Scenarios for the Internet of Things

The field of application for Internet of Things technology is much wider than we have seen so far. The control of processes and the quality of goods in manufacturing, logistics, service and maintenance are still valid applications. Moreover, new areas of applications have to be considered. The following exemplary scenarios will include the use of Internet of Things technology to support the offer of PaaS, the role of information service providers in the Internet of Things, the integration of end-users and opportunities through right-time business analysis and decision making.

Scenario 1: Product as a Service (PaaS)

The shift from providing products to providing services is a major trend in business model innovation. Not only software companies provide **SaaS** instead of selling software licenses, but more and more manufacturers follow this trend. Hilti, an international manufacturer and supplier of professional construction tools, launched what they call “Fleet Management”. The customer is no longer required to own a tool. Instead, Hilti offers its customers access to a range of tools on a contract basis and monthly fee, including additional services, such as repairs.

Today, the shift to **PaaS** is often hindered by missing means of performance measuring and billing as well as unsuitable pricing models. The Internet of Things offers a range of possibilities to support such PaaS scenarios. Sensors allow for the tracking of a product and the location of its current position. In addition, the usage times of a product can be exactly documented as well as the condition under which a product was used (e.g. the speed at which a car has been driven). Sensors also enable a company to monitor the condition of the product or parts and tools and thus support maintenance and repairs.

Scenario 2: Information Service Providers

If information can be measured and billed, new business opportunities for information service providers will be enabled. Data centres can provide storage and processing capabilities for



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Internet of Things-related data. Information service providers can aggregate and process information from different sources, thus providing a higher value of information. However, the value proposition which was only made possible through unique identification and billing in the Internet of Things differs significantly. Most important cost factors are the acquisition and aggregation of information (data) and the purchase and maintenance of needed information systems. A potential application scenario for information service providers is anti-counterfeiting. The problem of anti-counterfeiting is prevalent in the consumer goods market. Brand items, such as apparel and accessories or even worse drugs or spare parts are copied and sold as original products. This results in economic damage and can have severe impacts on the consumer side. The Internet of Things supports this scenario through the association of information to a product instance. The information service is aimed at the verification of the originality of a certain product in order to detect counterfeits. The information service provider has specialized on the verification of spare parts in the machinery and equipment industry as well as the automotive industry. The consumer – the buyer of the spare part or a service partner installing it – can submit a request to the information provider through the Internet of Things. The information service provider could query its information systems where information from different sources is aggregated and find out whether the serial number is valid

Scenario 3: End-user Involvement

The Internet of Things provides a new level of consumer integration into co-creation processes. While “living labs” have been used to integrate limited user groups into product and service development at a certain stage in the product life cycle, the Internet of Things will link all consumers across the life cycle of a product. Companies that will know how to utilize this huge potential will be in the lead for new business models in B2C scenarios. Other services include a payment scheme for product reviews, that is based on positive review ratings. Ciao11 is offering their users a small financial benefit as low as 0.5 pence every time their product rating is positively reviewed. In any case a high level of security and privacy as well as the freedom of choice to participate are mandatory. Through the use of a mobile phone, the end-user is enabled to supply and retrieve product related information at the point of sale – in this scenario a large supermarket chain. Both actions are supported by the use of RFID-chips or barcodes.



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Scenario 4: Right-time Business Analysis and Decision making

In production engineering, real-time usually refers to M2M-systems that record events and responds within milliseconds. In logistics, the time frame is not as well-defined, yet seconds, minutes, or even hours are sometimes still considered real-time, compared to longer traditional processes, such as transportation that causes information gaps of days or weeks.

Real-time is often used as a qualitative rather than a quantitative value to differentiate timely from out-of-date information distribution thus allowing acting instead of reacting. Therefore, it is more appropriate to use right-time business analysis and decision making. The amount of time between a business event and a decision is influenced by time periods, including data capturing latency, analysis latency, and decision latency. For perishable goods manual spot tests and visual inspections are common, but these cannot provide real-time monitoring or proactive strategies.

The Internet of Things provides real-time access and analysis opportunities across supply-chains or product lifecycles. Data analysis can be provided in proximity to things (smart objects), at the business premises or anywhere in the Internet of Things. Agile management strategies are enabled based on real-time availability and analysis of data. The envisioned scenario is based on an intelligent truck that combines different technologies and applications to increase the value of information and to a boost utilization of the Internet of Things infrastructure. Some easy tasks, such as navigation and dynamic routing, can be achieved without the Internet of Things, more complex tasks, such as tracking and condition monitoring, would largely benefit from it.

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Text Books

1. Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stefan Avesand, Stamatis Karnouskos and David Boyle, *From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence*, 1st Edition, Academic Press (Elsevier), 2014.
2. Dieter Uckelmann, Mark Harrison and Florian Michahelles (Editors), *Architecting the Internet of Things*, 1st Edition, Springer, 2011.
3. Hakima Chaouchi (Editor), *The Internet of Things: Connecting Objects to the Web*, 1st Edition, Wiley-ISTE, 2010.
4. Daniel Minoli, *Building the Internet of Things with IPv6 and MIPv6: The Evolving World of M2M Communications*, 1st Edition, Wiley, 2013.
5. Olivier Hersent, David Boswarthick and Omar Elloumi, *The Internet of Things: Key Applications and Protocols*, 2nd Edition, Wiley, 2012.
6. Arshdeep Bahga and Vijay Madisetti, *Internet of Things: A Hands-on Approach*, 1st Edition, Universities Press, 2015.

Reference Books

1. Dominique Guinard and Vlad Trifa, *Building the Web of Things: With Examples in Node.js and Raspberry Pi*, 1st Edition, Manning Publications, 2016.
2. Luigi Atzori, Antonio Iera and Giacomo Morabito (Editors), *The Internet of Things: A Survey and Emerging Technologies*, 1st Edition, Springer, 2014.
3. Cuno Pfister, *Getting Started with the Internet of Things: Connecting Sensors and Microcontrollers to the Cloud*, 1st Edition, O'Reilly Media, 2011.
4. Samuel Greengard, *The Internet of Things*, 1st Edition, MIT Press, 2015.
5. Peter Waher, *Learning Internet of Things*, 1st Edition, Packt Publishing, 2015.
6. Bernd Scholz-Reiter and Florian Michahelles (Editors), *Architecting the Internet of Things*, 1st Edition, Springer, 2011.
7. Florian Michahelles, Frédéric Thiesse, Arnold Schmidt and Elgar Fleisch (Editors), *Pervasive RFID: Technologies, Applications and Trends*, 1st Edition, Springer, 2008.
8. Klaus Finkenzeller, *RFID Handbook: Fundamentals and Applications in Contactless Smart Cards, Radio Frequency Identification and Near-Field Communication*, 3rd Edition, Wiley, 2010

Case Study

Case Study 1: RFID-Based Inventory Management in Walmart

Topic Covered: Cost and Benefits of RFID

Background:

Walmart introduced RFID technology to improve inventory visibility and reduce stock shortages across its supply chain.

Problem:

- Manual inventory tracking was time-consuming.
- Frequent stock-outs affected customer satisfaction.
- High labor costs and inventory inaccuracies.

Solution:

- RFID tags were attached to pallets and products.
- RFID readers automatically tracked inventory movement.
- Inventory data was integrated with Walmart's management system.

Benefits:

- Reduced inventory errors.
- Faster stock replenishment.
- Lower labor costs.
- Improved supply chain visibility.
- Higher customer satisfaction.

Learning Point:

Although RFID implementation required significant investment, long-term operational savings and efficiency outweighed the initial costs.

Case Study 2: IoT-Based Predictive Maintenance at Siemens

Topic Covered: Benefits of IoT

Background:

Siemens deployed IoT sensors on industrial equipment to monitor machine health.

Problem:

Unexpected equipment failures caused production downtime.

Solution:

- Sensors continuously monitored vibration, temperature, and pressure.
- Cloud analytics predicted equipment failures.
- Maintenance was scheduled before breakdowns occurred.

Benefits:

- Reduced downtime.
- Increased equipment lifespan.
- Lower maintenance costs.
- Improved production efficiency.

Learning Point:

IoT enables predictive maintenance, reducing operational expenses and improving productivity.

Case Study 3: Smart Agriculture Using ~~IoT~~ Sensors INTERNET OF THINGS

Topic Covered: Cost-Benefit Sharing

Background:

A farming cooperative implemented IoT-based smart irrigation.

Problem:

Individual farmers could not afford advanced IoT infrastructure.

Solution:

- Multiple farmers jointly invested in IoT sensors.
- Costs were shared among cooperative members.
- Data was shared through a common cloud platform.

Benefits:

- Reduced water consumption.
- Increased crop yield.
- Shared infrastructure costs.
- Improved resource utilization.

Learning Point:

Cost-benefit sharing makes IoT affordable for small and medium enterprises.

Case Study 4: EPCglobal Network in Pharmaceutical Supply Chain

Topic Covered: Billing Framework in EPCglobal Network

Background:

A pharmaceutical distributor implemented the EPCglobal Network for product tracking.

Problem:

Counterfeit medicines and inaccurate billing.

Solution:

- RFID-tagged medicines were tracked throughout the supply chain.
- Billing was automatically generated based on product movement.

Benefits:

- Accurate billing.
- Reduced counterfeit products.
- Improved supply chain transparency.
- Faster product recalls.

Learning Point:

Integrating billing capabilities into EPCglobal improves transparency and operational efficiency.

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Case Study 5: Rolls-Royce "Power by the Hour"

Topic Covered: IoT Business Models

Background:

Rolls-Royce shifted from selling aircraft engines to offering engine performance as a service.

Problem:

Customers faced high maintenance costs and uncertain equipment reliability.

Solution:

- IoT sensors monitored engine performance.
- Airlines paid only for engine operating hours.
- Maintenance was managed by Rolls-Royce.

Benefits:

- Predictable maintenance costs.
- Increased customer trust.
- Continuous revenue for the company.

Learning Point:

IoT enables service-based business models that generate recurring revenue.

Case Study 6: Philips Lighting – Lighting as a Service

Topic Covered: Business Model Innovation

Background:

Philips introduced "Lighting as a Service" for commercial buildings.

Problem:

Customers faced high upfront costs for lighting infrastructure.

Solution:

- Customers paid monthly subscription fees.
- IoT sensors monitored lighting usage.
- Philips maintained the lighting system.

Benefits:

- Reduced initial investment.
- Energy savings.
- Continuous service revenue.
- Improved customer satisfaction.

Learning Point:

IoT supports innovative subscription-based business models.

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Case Study 7: Amazon Go Smart Retail Stores

Topic Covered: Value Creation in IoT

Background:

Amazon Go stores use IoT, RFID, cameras, and AI for cashier-less shopping.

Problem:

Long checkout queues reduced customer convenience.

Solution:

- Smart sensors identified purchased products.
- Automatic billing through customer accounts.
- Real-time inventory management.

Benefits:

- Faster shopping experience.
- Reduced staffing costs.
- Accurate inventory.
- Better customer experience.

Learning Point:

IoT creates value by enhancing customer convenience and operational efficiency.

Case Study 8: Smart City Traffic Management in Singapore

Topic Covered: IoT Business Scenarios

Background:

Singapore deployed IoT-enabled smart traffic systems.

Problem:

Traffic congestion and inefficient road usage.

Solution:

- IoT sensors monitored vehicle movement.
- Traffic signals adjusted automatically.
- Real-time traffic information was provided to commuters.

Benefits:

- Reduced traffic congestion.
- Lower fuel consumption.
- Improved public transport efficiency.
- Better urban mobility.

Learning Point:

IoT enables intelligent city management and improved public services.

Case Study 9: DHL Smart Logistics Using RFID and IoT

Topic Covered: RFID and IoT Integration

Background:

DHL implemented RFID and IoT technologies for warehouse and logistics management.

Problem:

Manual shipment tracking resulted in delays and errors.

Solution:

- RFID tags identified packages automatically.
- IoT devices monitored shipment conditions.
- Real-time logistics dashboards were developed.

Benefits:

- Faster package tracking.
- Improved warehouse efficiency.
- Reduced delivery errors.
- Better customer service.

Learning Point:

RFID and IoT together provide end-to-end supply chain visibility.

Case Study 10: John Deere Precision Agriculture

Topic Covered: IoT Business Value Creation

Background:

John Deere integrated IoT into agricultural machinery.

Problem:

Traditional farming methods resulted in inefficient resource utilization.

Solution:

- Sensors monitored soil moisture, weather, and machine performance.
- Farmers received real-time recommendations.
- Farm equipment was connected through cloud services.

Benefits:

- Higher crop productivity.
- Reduced fertilizer and water usage.
- Improved equipment utilization.
- Increased farm profitability.

Learning Point:

IoT creates sustainable business value by improving productivity, reducing operational costs, and enabling data-driven decision-making.

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PART A (2 Marks)		
UNIT IV: INTEGRATED BILLING SOLUTIONS IN THE INTERNET OF THINGS		
Q.No.	Questions	Bloom's Taxonomy Level
1	Define RFID and explain its role in the Internet of Things (IoT).	L1
2	List the major cost components involved in implementing RFID systems.	L1
3	State any four benefits of RFID in supply chain management.	L1
4	What is meant by Cost-Benefit Sharing in IoT ecosystems?	L2
5	Define the EPCglobal Network.	L1
6	What is the purpose of integrating billing capabilities into the EPCglobal Network?	L2
7	Define a business model in the context of the Internet of Things.	L1
8	What is Business Model Innovation?	L2
9	List any four IoT business models.	L1
10	What is meant by value creation in IoT?	L2
11	Mention two examples of IoT-based business model scenarios.	L1
12	Differentiate between RFID implementation cost and operational cost.	L2
13	What are the advantages of subscription-based IoT business models?	L2
14	Explain the importance of billing mechanisms in IoT services.	L2
15	Identify any four application areas where RFID and IoT create business value.	L1
PART B(10 Marks)		
1	Explain the various cost components involved in implementing RFID and IoT systems with suitable examples.	L2
2	Discuss the benefits of RFID and the Internet of Things for organizations and customers.	L2
3	Analyze the concept of Cost-Benefit Sharing among stakeholders in IoT ecosystems with appropriate examples.	L4
4	Explain the technical framework for integrating billing capabilities into the EPCglobal Network with a neat diagram.	L3
5	Discuss the architecture and working of the EPCglobal Network in supporting IoT-enabled business services.	L3
6	Explain various Business Models for the Internet of Things with suitable industrial examples.	L2
7	Describe the concept of Business Model Innovation and explain how IoT enables innovative business strategies.	L4
8	Examine the methods of value creation in the Internet of Things and their impact on business performance.	L4
9	Compare traditional business models with IoT-enabled business models.	L4
10	Evaluate the economic feasibility of RFID and IoT implementation using cost-benefit analysis.	L5
11	Analyze the role of billing capabilities in enabling scalable IoT services across industries.	L4
12	Discuss exemplary IoT business model scenarios in Smart Manufacturing, Smart Healthcare, and Smart Cities.	L3
13	Evaluate the challenges and opportunities in implementing IoT business models in modern enterprises.	L5
14	Design an IoT-based business model for a smart retail or smart agriculture application, highlighting cost, value creation, and revenue generation.	L6