9 Integrated Billing Solutions in the Internet of Things

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Abstract The Internet of Things is one of the most promising technological developments in information technology. It promises huge financial and non-financial 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. In this chapter, an alternative concept, suggesting flexible pricing and trading of information, is proposed. On the basis of a beverage supply chain scenario, a prototype installation, based on an open source billing solution and the Electronic Product Code Information Service (EPCIS), is shown as a proof of concept and an introduction to different pricing options. This approach allows a more flexible and scalable solution for cost benefit sharing and may enable new business models for the Internet of Things.

9.1 Introduction

In this chapter there will be a detailed look at costs and benefits in the Internet of Things based on the findings from research on networked RFID. Even though networked RFID covers only a partial aspect of the Internet of Things, there are many similarities and overlaps with it. Numerous studies on costs and benefits of RFID have been published. This is hardly surprising, as one of the problems of RFID adoption has been the difficult calculation of a business case or a positive ROI (Schmitt and Michahelles 2008). Cost benefit analysis has been used as the main tool for economic analysis. According to a study by Seiter et al. (2008), 87% of companies planning to implement and 81% of companies that have already im-

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plemented RFID use cost benefit analysis. However, cost benefit analysis of RFID usage is most often based on best guesses (Gille and Strüker 2008, Laubacher et al. 2006).

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 cost for hardware, software, integration, maintenance, business process reengineering and data analysis are major hurdles in the process of deploying the Internet of Things.

Costs and benefits are not always balanced between all stakeholders. 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. For RFID adoption across supply chains, cost benefit sharing has been suggested to solve this issue. However, contrary to the widespread usage of cost benefit analysis, cost benefit sharing is not a common instrument (OECD 2007).

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 analyse 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.

In this chapter there will be a close look at current concepts to evaluate costs and benefits in the Internet of Things. The problems of cost benefit sharing will be discussed and a technical solution to integrate billing software within EPCIS is introduced as one possible approach for pricing and billing of information. This approach does not replace ROI-calculations prior to Internet of Things investments, but it provides a tool to offer billable Internet of Things services and it generates historic data over time that may be used to calculate an ROI for future investments based on real data rather than estimated data.

A prototype installation that has been developed at the LogDynamics Lab in Bremen is used to provide a proof of concept. A scenario from the beverage supply chain will illustrate how physical actions are transformed into EPCIS events that are used to calculate billing orders.

9.2 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 (even though some publications falsely stimulate this impression), results from cost analysis for RFID can be used as a basis for further calculations. In the following, there will be a short overview of the costs involved for RFID installations. While some of the financial data is based on other publications and cited correspondingly, other data is based on experience from corresponding purchases in the LogDynamics Lab at the University of Bremen between 2006 and 2009.

Agarwal (2001) lists six different costs of RFID deployment for manufacturing firms, including 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 reorganisation, and cost of implementing application solutions. It is not quite clear why Agarwal separates the cost of tags from the application process, while he sees cost for readers and their integration as one subject. 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 (Table 9.1).

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 edgeware for fixed and/or mobile environments • Installation and technical optimisation costs
3 Integration	• Systems integration costs	• Integration (to legacy systems)	• Systems integration costs including new interfaces as well as necessary updates, extensions, or replacements

			of existing systems
4 Training and reorganisation	• Cost of training and reorganisation	• Process (incl. redesign and human elements)	• Training cost • Reorganisation / 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 organisational)	• -	• -	• 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, standardised syntax and semantics, data conversion, synchronisation, trust concepts
7 Operational	• -	• Maintenance	• Cost for maintenance • Other operational costs for running (e.g., data storage and analysis), extending and improving the system

Table 9.1 Cost Levels for the Internet of Things

The *first cost level* in the Internet of Things includes mobile devices that are linked to physical objects. These can be RFID tags fixed to a product, as well as sensors, actuators (e.g., signal lights, power switches) or smart devices that combine multiple technologies. The price of RFID tags has been an important issue over the last years. User acceptance for tag prices differ in relation to the aggregation level of the product to which they are attached. In a study from 2004, 100 companies were asked what was the highest price they would accept for tags on item and unit level. On item level,a tag price of 0.10 € or less was most often required. On unit level a higher tag price was still reasonable (ten Hompel and Lange 2004). The measured average price for 2008 was 1.13 US-$ per tag, although this average represents High Frequency (HF) as well as Ultra-High Frequency (UHF) tags (IDTechEx 2009). UHF standard smart labels can be bought at a cheaper price, though. The lowest price that was offered to the LogDynamics Lab at the University of Bremen for a standard ISO/IEC 18000/Amd 1 (2006) compliant UHF self-adhesive inlay was 0.08 € in 2009. On-metal UHF tags with a robust housing usually cost in the range of 3 € to 7 €, due to the housing, the adjusted antenna design and the low quantities compared to smart labels. IDTechEx (2009) predicts an average price per tag of 0.22 US-$ by 2014 for both, HF and UHF tags. The discussion on RFID tag costs is mainly focused on passive RFID. For active RFID the cost per tag are considerably higher and will be typically in the range of 15 € to 75 €. While the lower end of the range is mainly defined by the cost for the battery and the housing, the higher end is more determined by the market position of the individual vendors. Usually non-standardised tags and readers have to be bought from the same vendor, thus leading to a long-term tie-up with one company. With the availability of ISO/IEC 18000-7 (2009), providing parameters for active air interface communications at 433 MHz, RFID tags for this frequency range can be bought from different providers. In fact, the Department of Defence (DoD) in the USA – one of the largest customers for active tags – placed its first orders of corresponding tags to Unisys, Savi, Systems and Processes Engineering Corp. (SPEC) and Northrop Grumman. Previously they were tied-up to Savi for sourcing active tags. Savi owns some intellectual property rights that require licensing from Savi to provide ISO/IEC compliant active tags. Nevertheless, the DoD claims that they pay half the price for the Unisys tags, compared to the prices they had to pay for the previous proprietary SAVI tags. Unisys themselves use Identec Solutions and Hi-G-Tek as subcontractors to supply the tags. The active tags need to comply with the DoD military standards, which require safe and reliable operation in helicopters (Swedberg 2009). The corresponding tests are quite expensive and add to the high cost of these tags. Other active tags operate in the range of 860 to 960 MHz, 2.4 GHz or in the Ultra-Wide-Band (UWB) range. These tags sometimes offer additional features, such as location sensing. Considering the prices of active tags and their successful deployment in industry, the isolated price discussion about passive tags seems rather inappropriate. Consequently, the price for the tags should always be compared to the benefit it generates. However, if RFID is compared with other IT-investments, one has to bear in mind the reoccurring costs for tags. When we consider the integration of sensors, actuators and smart devices in the Internet of Things there will be even more expensive ubiquitous mobile technologies that need to be paid for. Therefore, the costs of mobile devices and their installation on things will remain a major topic in the cost discussion for the Internet of Things.

The *second cost level* includes aggregation devices and aggregation software, such as readers, antennas, cabling, controllers and other edge hardware and software as well as the corresponding installation costs. RFID reader kits can be as cheap as 50 € for a HF reader with USB connection, some sample tags and a software that triggers websites or applications[92]. These new offerings will allow RFID to be used in smart home scenarios, and for fun purposes. In the mid-term, they may also put pressure on RFID offerings for industrial purposes. Today, ISO/IEC

[92] A popular example is provided by Violet (www.violet.net).

18000-6c compliant readers with 4 antenna ports can already be bought for under 1,000 US-$ in the USA, while prices in Europe currently are still higher and usually are in the range of 1,300 € to 2,500 €. In some publications (e.g. Feinbier et al. 2008) reader costs are considered to be correlated with functionality. Instead, the price is more related to the company position, the sales strategy of the individual company, and the number of middlemen involved. Corresponding UHF antennas in general are in the price range of 80 € to 300 €. Antenna cables can be considered to cost about 10 € to 30 €. Handheld RFID Personal Data Terminals (PDT) are priced between 1,000 € and 4,000 €. RFID printers start at about 1,000 € and may go up to 30,000 € or more for integrated and automated labelling solutions. Other hardware costs include hardware portal frames to hold the reader and antennas. Some retailers have used large metal housings to shield between dock doors in order to avoid false reads. Newer installations rather use intelligent filtering mechanisms provided by corresponding middleware components. The setup of the gates may require considerable costs for hardware and installation. An RFID site survey will cost about 1.000 € (Feinbier et al. 2008). Feinbier et al. (2008) consider 20,000 € installation cost per read point in a harsh environment, such as the steel industry. This seems rather high for standard dock-door installations, but still illustrates that the cost for installation should not be neglected.

Controllers and middleware are used for managing low-end hardware and abstracting these from the applications. Sometimes the middleware is further divided into solutions interfacing with hardware (edgeware) and the middleware interfacing with applications. In this case, middleware may be considered to be part of the integration level.

The *third cost level* includes all integration costs to legacy systems, middleware and updates of existing system. The cost for the middleware acquisition is further increased by the necessary installation cost. Middleware can be based on freeware, such as the Fosstrak-system[93], or it may also be provided by large integrators, such as IBM[94], software giants, such as Oracle or SAP[95], EDI-specialists, such as Seeburger[96], and RFID-specialists, such as Savi[97] and REVA[98]. In the Internet of Things, middleware does not only link to internal applications, but additionally allows multidirectional communication between companies, end-users and public institutions (see level six).

Additionally, costs for updating applications, such as Enterprise Resource Planning (ERP), Supply Chain Management (SCM), and Product Lifecycle Management (PLM) systems, need to be considered.

[93] www.fosstrak.org

[94] www.ibm.com

[95] www.sap.com

[96] www.seeburger.com

[97] www.savi.com

[98] www.revasystems.com

The fourth level includes cost for educating the project team and end-users as well as cost of reorganisation. The necessity of training and education for end-users is quite important, because the Internet of Things requires fundamental knowledge about different technologies, such as Auto-ID and sensors as well as knowledge about real-time data handling and analysis. Additionally, certain aspects of the Internet of Things raise privacy and security concerns of workers and unions, which may lead to a total failure of the project. Training and education help to provide the corresponding skills and to address technology-related fears. The cost of reorganising the business processes result from traditional management tools, such as business process reengineering or newer approaches, like business model innovation. As a result, further infrastructural investments may be required. Ford Cologne (Germany) for example, paved a new roundabout for optimising their car distribution process to vessels, trains, trailers and storage areas, based on RFID and automated access gates (Harley 2008). It can be estimated that the cost for the new roundabout exceeded the cost of the RFID infrastructure. While this example shows an investment in a single process optimisation, new business models may require extensive organisational changes.

The *fifth cost level* includes new internal applications, which are rolled out in a firm to unleash the full potential of the Internet of Things. The costs include standard software, such as PLM or SCM systems, as well as individual software and all associated costs for installation, customisation and training. These applications interface to the Internet of Things and provide tools for data-entry and retrieval, analysis, planning, forecasting and more.

The *sixth cost level* considers the fact that an Internet of Things needs communication and collaboration across enterprise boundaries, non-commercial stakeholders, such as governmental institutions, and end-users. While middleware provides some functionality in the Internet of Things for collaboration and communication, further investments are necessary. Some suppliers, especially in retail, have to consider an investment into an Electronic Data Interchange (EDI-) infrastructure, as EDI represents the current state of the art. Even the EPCglobal network will not replace EDI, as it does not cover issues such as purchasing or forecasting. Software-related costs can start from tens of thousands of Euros and may reach several million Euros in large installations. Others will need to provide Web-interfaces to access and contribute to the Internet of Things.

Negotiations with partners, suppliers and customers about data requirements and service level agreements will be necessary. For machine-to-machine communication, detailed syntax and semantics are required. Finally, trust and security issues need to be addressed in a networked environment.

The *seventh cost level* covers operating costs for maintaining, running, improving and extending the system. The hardware and software need to be maintained and updated regularly. So, an annual amount of 10% to 15% of the hardware and software investment cost should be considered. Electricity costs, to operate the infrastructure, are usually quite low in comparison with the other costs involved. However, as Green IT initiatives are becoming more and more significant, the

Internet of Things is no exception. Above all, the labour involved to provide high-quality product data has to be taken into account. As these costs are difficult to calculate, they are most often omitted from any calculations. Besides keeping the technical infrastructure alive, day to day tasks, such as data storage and analysis as well as overall improvements and upgrades to cope with growth, are adding up to considerable recurring costs.

In an early study from AMR Research (McClenahen 2005), the costs for system integration, changes for supply-chain applications and for data storage and analytics were considered to reach between 8 and 13 million US dollars for a full implementation of RFID for a Consumer Packaged Goods (CPG) manufacturer, shipping 50 million cases per year (see Table 9.2).

Cost category	Assumed cost
Tags and readers	$5 million to $10 million
System integration	$3 million to $5 million
Changes to existing supply-chain applications	$3 million to $5 million
Data storage and analytics	$2 million to $5 million
Total	$13 million to 23 million

Table 9.2 Assumed Cost of Compliance for a Full-fledged RFID System at a CPG Manufacturer (McClenahen 2005)

A study among 137 Wal-Mart suppliers showed though, that the initial average cost was only about 500.000 US-$ (Incucomm 2004). Hardgrave and Miller (2006) consider that there are three reasons for the deviation between estimated and actual cost. First, they consider that several suppliers have only implemented limited installations. This may change over time, though, if RFID is becoming more ubiquitous. Second, they believe that the RFID cost infrastructure has decreased and continues to do so. However, considering the added costs in an Internet of Things, including multiple different devices (e.g., sensors), it can be expected that the overall cost will be higher than for an isolated RFID deployment. Third, they consider that the deployment costs are lower than expected. But again, this may relate to the limited integration depth of ‘slap and ship’ installations. The Internet of Things requires a deeper integration across company boarders and multiple stakeholders and will therefore add to higher overall cost. Fourth, they consider that the cost of data storage is much less than envisioned by McClenahen. Once more, this may relate to the limited scope of integration on the one hand and missing revenue opportunities on the other. No matter if the final cost will be closer to $500.000 or to $23 million – the investments need to be justified by a corresponding ROI.

There are different options to pay for the costs of RFID adoption. These differ between implementation and operation. In a study from Bensel and Fürstenberg

(2009), more than 100 end-user companies have been asked which payment options they prefer for implementation and operation. For implementation there was a clear preference towards a target agreement-based payment scheme. Variable payment options based on number of tags, data volume, process times or pay-per-read were not well accepted (see Table 9.3).

	Transponder volume	Data volume	Process times	Pay per read	Work package	Target agree-ment	Fixed monthly payment	Single payment
Always true for me (weighting factor 2)								
Implementation	12	0	0	0	19	26	2	12
Operation	17	0	2	2	5	22	7	7
Usually true for me (weighting factor 1)								
Implementation	12	3	5	2	21	30	5	12
Operation	10	12	7	5	12	17	12	5
Neutral (weighting factor 0)								
Implementation	9	7	15	10	21	14	17	15
Operation	19	12	12	12	28	21	19	21
Usually not true for me (weighting factor -1)								
Implementation	19	26	17	20	14	5	14	7
Operation	14	14	14	16	7	7	9	12
Not at all true for me (weighting factor -2)								
Implementation	48	64	63	68	25	25	62	54
Operation	40	62	65	65	48	33	53	55
Weighted results / average								
Implementation	-0.79	-1.51	-1.38	-1.54	-0.05	0.27	-1.29	-0.79
Operation	-0.50	-1.26	-1.33	-1.37	-0.81	-0.12	-0.89	-1.03

Table 9.3 Preferred Payment Options for Implementation and Operation (based on Bensel and Fürstenberg 2009)

One of the reasons for this could be the missing technical infrastructure to measure and bill the corresponding usage. For operation, a usage-based accounting did receive higher acceptance levels. While pricing based on target agreements still was preferred, a pricing scheme based on transponder volume, followed as second preference.

It may be assumed that one of the reasons for the reluctance to use usage-based pricing schemes, based on pay per read, process times or data volume, may be once more the lack of an integrated technical billing solution.

9.3 Benefits of RFID and the Internet of Things

There have been numerous analyses to identify and structure benefits of RFID in supply chains. While the benefits are named in relation to RFID adoption, the corresponding IT infrastructure, including e.g. the EPCglobal Network, is most often implied. Baars et al. (2008) have identified four different approaches towards systemisation of RFID benefits:

- Collecting and grouping – benefits are collected and grouped. Examples for these types of studies are Agarwal (2001) and Li and Visich (2006)
- Layer of impact – benefits are structured to impact layers such as short term and long term automation, informational and transformational benefits, proven or potential (Bovenschulte et al. 2007, Hardgrave et al. 2008)
- Locus of impact – these studies highlight who benefits, thus it automatically considers benefits to multiple stakeholders (Wong et al. 2002, Hardgrave et al. 2008, Tajima 2007)
- Indicator system – established evaluation systems, such as Balanced Scorecards, are used to structure RFID benefits (Schuster et al. 2007, Scholz-Reiter et al. 2007)

Sometimes combinations of these structures are used (e.g. Hardgrave et al. 2008). For this chapter it will be important to understand who benefits (locus of impact) from RFID and the Internet of Things usage on an inter-organisational or even end-user level. The following list is based on Wong et al. (2002), Hardgrave et al. (2008), and Tajima (2007), but additionally includes benefits to society. Service and infrastructure providers are not included, as they benefit only indirectly, for example through sales, services and new business opportunities, rather than directly from accessing the Internet of Things.

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[99]
- *Subsequent fault reduction:* inaccurate and incomplete visibility may lead to false decisions and can be avoided through the Internet of Things[100]
- *Faster exception management (agility):* capability of responding to unplanned events in a timely manner before critical problems escalate
- *Asset management:* better asset utilisation 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 (Hardgrave et al. 2008)

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 (Aberdeen 2007) or legislators and regulators

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

- *Material handling:* time (labour) savings for loading / unloading of trucks, administrative overhead at the goods receipt[101], cross-docking, customs clearance,

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[99] In a survey among 141 companies, 70% estimated a deviation between real and IT-data of up to 10%. 13% of the companies even estimated a higher inaccuracy of 10% to 30% (Gille and Strüker 2007).

[100] As an example Wal-Mart reduced unnecessary manual orders, due to inaccurate stock visibility by 10% (Hardgrave et al. 2008).

delivery lead times and reduced delays, faster inventory, goods receiving, loading and unloading as well as reduced human errors through Auto-ID
- *Space utilisation:* achieved through reduced buffers and reduction of product storage incompatibilities (e.g., placement of hazardous goods[102]), based on better data accuracy through RFID usage

Retailer benefits include:

- *Customer service:* RFID can be used to simplify checkouts and payments as well as for promotion management (Thiesse and Condea 2009)
- *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[103]
- *Promotion execution:* RFID and the Internet of Things may be used to obtain better visibility for timely placements of promotional items[104]
- *After sales services:* in after-sales service, RFID may be used for warranty issues, 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 UN/EDIFACT in 1988

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[101] Times for loading and unloading of trucks can be reduced up to 13%, administrative overhead may be reduced up to 70% and time savings at the goods receipt may be as high as 90%, if bulk reading can be applied (Grote 2006).

[102] A solution approach for incompatible products has been researched in the OPAK project (Schnatmeyer 2007).

[103] Wal-Mart has achieved up to 30% reduction in out-of-stocks by using RFID-tagged cases to improve shelf-stocking processes (Hardgrave et al. 2006). Other companies report 10% to 50% reduction on out-of-stocks resulting in a gain of 7.5 to nearly 25 sales basis points (Laubacher et al. 2006).

[104] Procter & Gamble estimates an average of 20% increased sales by timely placements (Collins 2006).

- *Infrastructure optimisation:* e.g., roads, public transportation

These benefits are based on technologies in the Internet of Things. Some (e.g., quality control in production) may not require an overall Internet of Things implementation, but the Internet of Things will improve these individual tasks by sharing information in networked environments. The list of benefits mentioned above shows quite clearly that numerous stakeholders may benefit from an Internet of Things, but unfortunately not to the same extent. Additionally, several of these benefits cannot be achieved alone, but only in collaboration with other stakeholders.

The measurability of the benefits should be considered. While measurable benefits most often refer to monetary aspects, there are as well qualitative benefits that can be measured, such as customer satisfaction. Measurability may be subjective to individual projects, for example time measurements are not allowed in some companies.

9.4 Cost Benefit Sharing

Costs and benefits of the Internet of Things that have been explained in detail in the last paragraphs are not evenly distributed between the stakeholders. Cost benefit sharing models may be used as a tool to balance these asymetries. Cost benefit sharing in combination with RFID has been researched by several authors (Riha 2009, Hirthammer and Riha 2005, Bensel et al. 2008, Wildemann et al. 2007). Sharing benefits and investments in multi-tiered situations is seen as a core requirement for wide-scale deployment of RFID (Schuster et al. 2007). 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."

This rather limited definition with a focus on providing an incentive to otherwise non-profiting companies is extended by Riha (2009):

> "Cost benefit sharing (CBS) is a method to accomplish process changing projects in networks. It is based on a stakeholder oriented total cost analysis of all packages of measures in a project. Based on the achieved transparency of positive and negative effects a win-win situation is provided through reallocation strategies for all stakeholders. Therefore an incentive to a network-wide optimisation is given."

In this definition a cost and benefit transparency between the stakeholders is suggested to achieve a win-win situation. Unfortunately, this level of transparency is quite often not wanted by companies.

The structural requirements for cost benefit sharing can be quite complex and cost intensive. Hirthammer and Riha (2005) even suggest having different institutions on a structural level, including a board of company representatives, a mediator, and a company independent controller. 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
4. Cost benefit sharing
    a. Calculation of costs
    b. Evaluation of benefits
        i. Calculate monetary benefits
        ii. Calculate qualitative benefits
        iii. Evaluate total benefit
        iv. Calculate share of benefit
    c. Distribution of costs
5. Implementation of actions proposed in step 3
6. Controlling
7. Feedback loop to adjust the system to external dynamics

While tools have been developed to calculate costs as well as benefits, it becomes apparent, why cost benefit sharing approaches have failed to gain wider acceptance. The effort involved to install and maintain such a system exceeds the advantages, in most cases.

One of the fundamental mistakes in the usual cost benefit sharing models is to look for a 'fair' scheme to level cost and benefit, rather than to look for a model that accepts market forces. Hirthammer and Riha (2005) suggest using a mediator to settle disputes, which does not seem appropriate for highly-dynamic information sharing processes.

An IT infrastructure that supports a self-regulating approach, based on supply and demand of information and assisting free competition, may be more promising.

9.5 A Technical Framework for Integrating Billing Capabilities into the EPCglobal Network

As discussed in chapter 1, a possible solution to overcome the problems of cost benefit sharing in the Internet of Things may be based on an integration of a billing solution into the EPCglobal Network. In a prototype test scenario that has been set up at the LogDynamics Lab in Bremen, two open source products have been chosen for implementation. The well-known Fosstrak[105] EPCIS software has been integrated with jBilling[106], 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[107]. 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

Any charge to a customer corresponds to a purchase order[108] in jBilling. These include subscriptions, single purchases, taxes, and interest.

Figure 9.1 shows the overall billing process between Fosstrak and jBilling. The accounting process may be triggered by an event, such as a pallet with an RFID tag passing a dock-door (1a, 1b).

[105] www.fosstrak.com

[106] www.jbilling.com

[107] A first trial of using MySQL for jBilling has produced several error messages.

[108] For brevity, purchase orders are referred to as orders in jBilling.

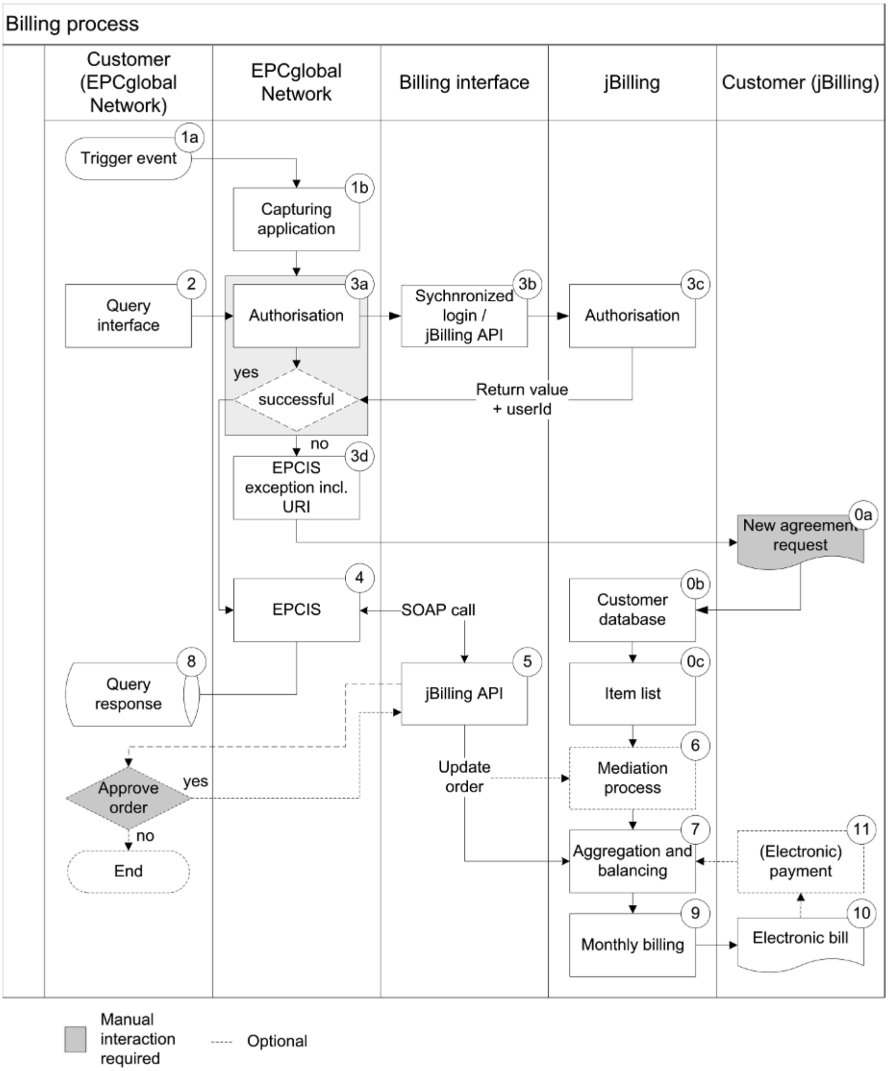

Fig. 9.1 The Billing Process between Fosstrak and jBilling

This event may already start a billing process if we consider for example deposit fees for returnable transport items. 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 (Figure 9.2) at the LogDynamics Lab.

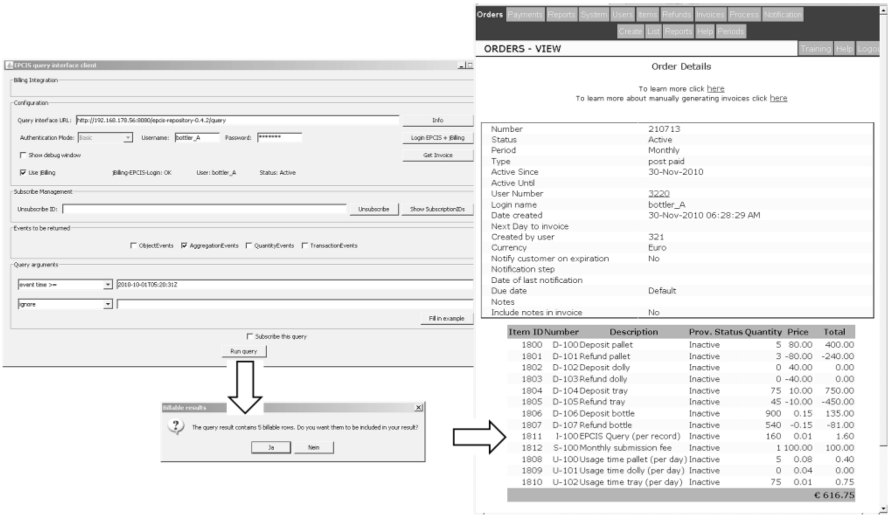

Fig. 9.2 Integrated Login Procedure and Workflow between Fosstrak (EPCIS Query Interface) and jBilling

Currently, only basic authentication is enabled. More sophisticated security functions could be supported in a future version. For the prototype installation we use the same login and password data for both systems. If the input data is null or missing, jBilling generates an API exception (jBilling 2010). Otherwise jBilling returns different integer values as described in Table 9.4.

Integer value	Description
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.

Table 9.4 Return Values for the Authorisation Process from jBilling (jBilling 2010)

An integer value for the user ID will be used further on to link purchases (orders) to a specific account. 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). For further usage in the Internet of Things it would be favourable, 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[109] 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 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. An approval by the user may be necessary, for example. if the information purchase is not covered by a flat-fee subscription. 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 labour, electronic bills (10) and electronic payment (11) will be preferred. The login screen to jBilling and the EPCIS (Figure 9.2) also offers an opportunity to retrieve last invoice values. Additionally, an invoice is sent via e-mail or traditional postal services to a defined recipient.

A Usage Scenario within the Beverage Industry

The described integration of a billing solution offers flexible usage for multiple industries and applications. To illustrate the prototype installation, a scenario from the beverage industry has been used. There may be different events that need to be processed for the billing system. Querying information is just an example. Usage-based fees and deposits for Returnable Transport Items (RTI), or initial costs for infrastructure could also be handled through the billing system. Any event where customers are using measurable services may be communicated to the billing system. The billing mediation process is able to differentiate the different events and to calculate individual prices, based on business rules.

[109] SOAP is a standard WEB services protocol for exchanging structured information in distributed environments.

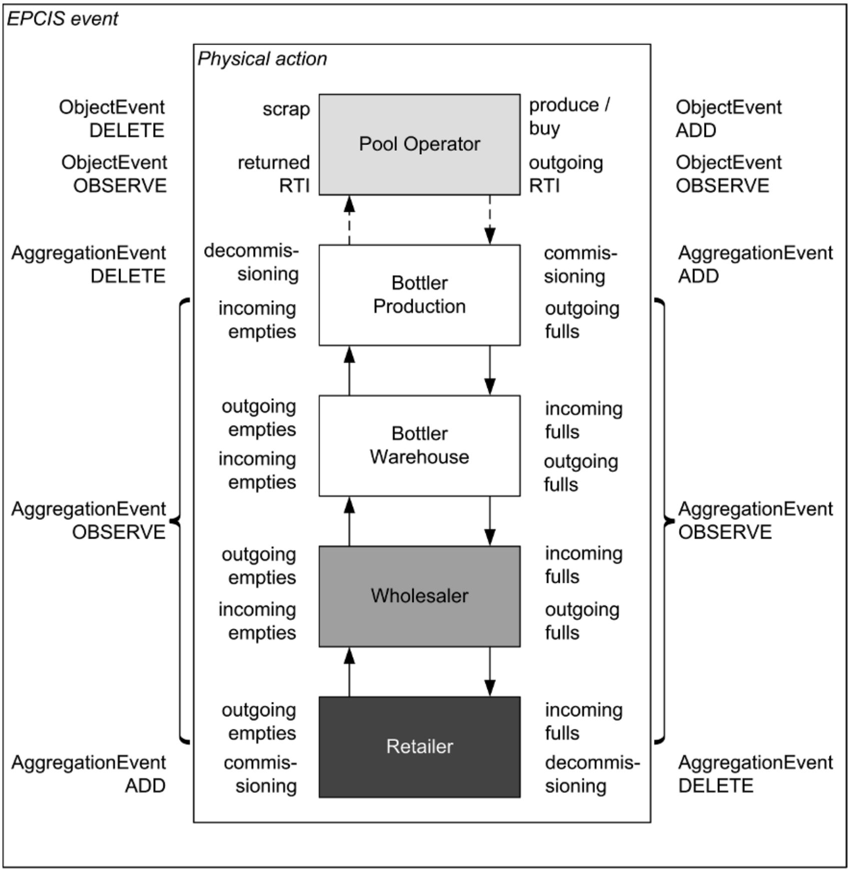

Fig. 9.3 A Simplified Supply Chain Scenario in the Beverage Industry

In a simplified scenario in the beverage supply chain, the EPCglobal Network may be used to track the flow of goods between pool operator, bottler, wholesaler and retailer (Figure 9.3). The pool operator provides RTIs (e.g., pallets, dollies, trays) to the bottler, who fills the pallets, stores and ships them to the wholesaler. At the end of production the different RTIs are aggregated to one pallet. The wholesaler delivers the pallet to the retailer and in return collects pallets with empty bottles. These are returned to the bottler to be refilled or to the pool operator in case of over-capacities or repair requests. The integrated billing times may include beverage prices, usage-based pricing and deposits for RTIs, as well as initial, monthly and usage-based fees for information access. Table 9.5 lists the different cost types, the corresponding EPCIS events and the associated price structure.

Cost type	Event / calculation	Price structure
Beverage price	e.g. BottlerOutgoingGoods (Aggregation-Event, OBSERVE)	Per pallet
Deposit (pallet, dolly, tray, bottle)	e.g. BottlerEndOfProduction (AggregationEvent, ADD)	Fixed price, per event
Deposit refund (pallet, dolly, tray, bottle)	e.g. BottlerEndOfProduction (AggregationEvent, DELETE)	Fixed price, per event
Usage-based fee (pallet, dolly, tray)	e.g. RetailerOutgoingGoods (AggregationEvent, OBSERVE) - RetailerIncommingGoods (AggregationEvent, OBSERVE)	Usage-based, per day
Initial fee (optional)	Account opening	Fixed price, only once
Monthly IT infrastructure rent or lease (optional, e.g. for readers)	Initial contract, contract period (e.g. 12 month)	Percentage of purchasing cost, per month
Monthly information access	Initial contract, contract period (e.g. 12 month)	Flat fee, per month
Premium query	Queries that are not covered through monthly contract	Usage-based, per event

Table 9.5 List of Different Options for an EPCIS-based Pricing in a Beverage Scenario

The table shows different pricing schemes for products (beverage), RTI (usage-based fees and deposit), account opening (e.g., initial fee for new stakeholders), infrastructure rent or lease (e.g., for RFID readers), monthly information access, including standard queries, covered by a subscription, and premium services that require extra payments. It is quite obvious that this is just an example of using a billing system in combination with applications in the Internet of Things, such as the EPCIS. Nonetheless, it illustrates the flexibility that can be achieved for pricing beyond ‘physical’ product pricing. The actual pricing scheme will depend on the individual business model.

Instead of an internal billing solution, billing service providers in the Internet of Things could offer their services. Unfortunately, these services usually require a minimum fee (e.g., 0.15 €) per transaction, which is much too high for low-value queries. A company offering information services through the EPCglobal Network, could have millions of billable low-value events. However, there is no need for a micro-payment system, as these events may be consolidated in a periodic (e.g., monthly) bill. If the proposed integration of billing and the Internet of Things proves to be beneficial, billing service providers may change the pricing models to participate in this market. A further advantage of an internal billing solution is a higher level of flexibility in dynamic pricing and a tighter integration possibility with internal applications. However, the effort for installing and maintaining an internal business solution should not be underestimated.

9.6 Discussion and Outlook

In this chapter, costs and benefits of the Internet of Things have been presented and the concept of cost benefit sharing has been evaluated. A technical solution has been provided for integrating billing into the future Internet of Things. Therefore, a synchronisation of material, information and financial flows has been achieved. The concept has been validated by developing a prototype that combines an open source billing solution with an open source implementation of the EPCglobal EPCIS standard. A beverage scenario has been used to illustrate the technical prototype.

The overall goal of the prototype integration of a billing system with EPCIS was to provide a means for charging for information access, thus enabling a free trade of information within an Internet of Things, based on market forces. It may be used as a simple alternative to timely and costly cost benefit sharing agreements. Another important effect will be to collect historical data about the value of information over time, based on real values rather than on guesses for future ROI calculations.

A phased approach will probably be necessary to validate the acceptance and applicability of the concept. Firstly, there may be a trial for internal purposes, for example. to split IT infrastructure costs between different departments. Secondly, limited networks, such as closed loop RTI-applications may adopt billing as described in the beverage scenario above. Thirdly, an open billing opportunity in a ubiquitous Internet of Things would not only solve current problems, such as a missing ROI in a lot of calculations, but it would also enable new business models.

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