Implementation and Evaluation of an Incentivized Blockchain-Based Deposit-Refund System

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Niklas Sauer

Abstract

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Acronyms

HPE	Hewlett Packard Enterprise
DPG	Deutsche Pfandsysteme GmbH

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1 Introduction

1.1 Motivation

Compared to glass, plastic or aluminum packaging represents a lightweight and durable alternative. The impact of lightweight materials on shipping costs is non-negligible and has therefore been leveraged in the beverage industry for the past 30 years. Simultaneously, the quote of reusable bottles (Mehrwegflasche) has steadily fallen (from 72% in 1991 [7, § 9 Abs. 2] to 45,1% in 2014 [3]), which prompted German lawmakers to introduce a system of returnable one-way bottles (Einwegflasche) in 2003 on which a deposit is payable [7, § 9 Abs. 2].

Contrary to expectations [7, § 8], this regulation has not stopped the influx of one-way bottles but has rather benefitted bottlers. Whenever consumers pollute by leaving behind one-way bottles, an instant 25 cent profit – assuming that no one else has returned them – is generated for the producer. This passive profit was estimated to have reached up to 175M€ in 2015 alone [5].

Ideally, this pollution of the environment should be punished by splitting non-claimed deposits of one-way bottles between environmental agencies and those consumers who regularly purchase reusable bottles, which save more resources. As a further consequence, those consumers who repeatedly neglect to return their one-ways should be required to pay a higher deposit. Such a revised approach can hopefully maximize the number of returned one-way bottles and effectively steer users towards reusable ones. Otherwise, a further decline may be inevitable and is shown to have had a direct negative impact on global warming, in addition to the excess amount of waste produced hereof [2].

When considered on a case-by-case basis, this problem inherently deals with deposits of very low extrinsic value. Moreover, such a system has to manage account balances and track the movement of value, increasing the appeal and likelihood for external attacks. Therefore, implementing the proposed approach by utilizing smart-contracts and micro-transactions on the Blockchain may come to mind upon choosing the underlying architecture. But how does such an implementation look like; are there special considerations to be made?

1.2 Goals and Scope

Since no research on the feasibility of this approach has been undertaken for an application as specific as this one, the study focuses on the end-to-end development process, including design, implementation and deployment. The objective of the research is to guide Hewlett Packard Enterprise (HPE) and interested parties alike in developing a mindset suitable for migrating applications onto decentralized platforms and evaluate if this Blockchain-based implementation can withstand the requirements of an incentivized deposit-refund system. The results are relevant as they reduce the go-to-market time of the previously outlined solution to stop the influx of one-way bottles, which in turn reduces pollution and warming of the earth (comp. 1.1), a serious concern to today's society. Moreover, HPE can offer more profound Blockchain-related consulting services through the insights gained.

It shall be explicitly noted that the study does not cover analyzing the effectiveness of employing such a system (i.e. reducing the usage of one-way bottles) or verifying wether this represents the best possible approach. Similarly, the legal framework and ethical questions pertaining to its usage are disregarded.

1.3 Thesis Overview

Chapter 2 reviews the relevant literature and is intended to answer all descriptive research questions that help define the project variables. The key concepts are then applied in chapter 3 as part of the architectural overview derived from the functional requirements of an incentivized deposit-refund system given earlier in the chapter. At the same time, the criteria to evaluate the forthcoming implementation are selected. Chapter 4 then describes the procedure to implement the solution, after which the actual evaluation may take place in chapter 5. Chapter 6 uses the results to draw a conclusion, discuss probable alternatives, as well as any limitations encountered during the study. Finally, chapter 7 summarizes the thesis's goals, methodology and results and is followed by chapter 8 to highlight interesting related research opportunities.

2 Theoretical Framework

2.1 Deposit-Refund System for Bottled Beverages in Germany

2.1.1 Legal Basis

Anticipating the depletion of capacity in disposal sites and due to the considerable share in waste generated by packaging [1] [4], German federal government enacted an ordinance regarding the avoidance of packaging waste (*Verordnung über die Vermeidung von Verpackungsabfällen*, short: *Verpackungsverordnung* or *VerpackV*) in 1991 which stipulates that packaging [6, § 1]:

- must be minimised to an extent necessary for protection and marketing of goods
- must be reused where possible
- must be recycled if reuse is not applicable

These objectives were supported by introducing the:

Obligation to take back packaging

Producers and distributors of packaging are obliged to take back packaging free of charge, restricted to those goods of type, shape, size and material found within their stock [6, §§ 4-6]. Distributors with a retail area of less than $200m^2$ are further exempted to the same brands. This duty may be only be ignored if a distributor participates in a system which ensures the periodical collection of waste [6, § 6], known and implemented as a refuse recycling system (*duales System*) in 1990 [4].

Obligation to levy deposits on beverage packaging

A deposit is to be charged by the distributor that will be refunded to the purchaser upon return of the bottle. This duty is applicable on all levels of trade involving domestic beverages sold in non-reusable packaging (*one-way*) [6, § 7] and becomes

[1] Recycling rate of packaging was below 50% in the early 1990s (20% for aluminium and plastic) [**GVM2010**].

effective as soon as the quote of reusable beverage packaging falls below 72% [1] [6, § 9].

figure showcasing development of aggregated reusable packaging quote

Starting in 1997, the threshold to levy deposits has been surpassed steadily [**BMU 2010a**], requiring an additional assessment of the situation to ensure that the fluctuation does not represent a short-term development [6, § 9] [4, p. 5]. Although obvious at glance, the outcome of a compulsory deposit-refund system only became official on July 2nd 2002 [**Geyer/Smoltczyk 2003**], after a lawsuit lead by multiple bottlers and distributors had delayed the initial announcement [1]. Introduction of this mandatory system was scheduled for Jan 1st 2003 [**Geyer/Smoltczyk 2003**].

2.1.2 Amendments

The German packaging ordinance underwent several revisions, of which the most important changes affecting the current state shall be highlighted in the following:

1998

Trims deposit obligation to those beverages for which the quote of reusable packaging has fallen when compared to 1991, though still necessitates that overall aggregated quote undercuts threshold of 72% [**Flanderka 1999**]. Even though all five segments (beer, mineral water, carbonated soft drinks, fruit juice/non-carbonated soft drinks and wine) have failed this comparison [**BMU 2010a**], juices/non-carbonated soft drinks and wine are exempted because their decline and market volume has not been regarded significant enough to justify the costs introduced with such a system [**BMU 2002**] [4, pp. 6, 9].

figure showcasing development of reusable packing quote in each segment

2005

Reduces different deposit classifications to single deposit worth 0.25 € valid for all applicable beverages with a filling volume between 0.1 - 3.0 litres. Furthermore, ecologically advantageous packaging is admitted the same treatment and classification as that of reusable packaging which represents an important shift of thought since the sole utilisation of packaging has been considered inferior to its reuse with regard to all ecological aspects [**BMU 2010c**]. Accordingly, the new goal is to promote the use of ecologically advantageous packaging with a target of 80% market dominance

[1] Aggregated quote derived from weighted average of percentages of reusable packaging encountered across individual segments in 1990 [6, § 9] [**Rummler/Schutt 1991**]

[8]. This amendment also adds non-carbonated soft drinks and mixed alcoholic drinks to the list of beverages subject to deposits (irrespective of the reusable packaging quote experienced) while simultaneously protecting dietary products from deposits [**BGBl. 2005**] [**Flanderka/Stroetmann 2009**]. Finally, retailers are required to take back any bottles made from a beverage packaging material (glas, metal, paper and plastic) also sold by that store [**BMU 2010c**]. Previously, return has been limited to bottles of same shape, size [..] and type (comp. 2.1.1). This regulation attempts to stop isolated deposit-refund systems which arose because discounters created their own specially shaped bottles [**Flanderka/Stroetmann 2009**]. To conform with this change, industry and commerce established the Deutsche Pfandsysteme GmbH (DPG), responsible for setting up a nationwide system [**BMU 2010c**].

2008

Orders distributors to clearly mark bottles as being obliged to a deposit. Further, distributors are demanded to participate in a nationwide deposit-refund system to enable the mutual settlement of claimed deposits [8, § 9]. Lastly, the exemption for dietary products is reduced to infant nutrition. This acts as a measure to counteract increasingly false product declarations attempting to forego deposits [**BGBl. 2008**] [**Flanderka/Stroetmann 2009**].

2.2 Decentralized Applications

2.2.1 Architecture and Components

2.2.2 Platforms

2.3 Web Service Quality

3 Concept

3.1 Solution Overview

3.1.1 Functional Requirements

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3.3 Architecture

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5 Evaluation

6 Conclusion and Discussion

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8.2 Adoption and Scalability

8.3 Additional Fields of Application

Bibliography

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[3] *Abfüllung von Getränken in Mehrweg- und ökologisch vorteilhaften Einweggetränkeverpackungen*. Umwelt Bundesamt, 2014.

[4] Uta Hartlep and Rainer Souren. *Recycling von Einweggetränkeverpackungen in Deutschland: Gesetzliche Regelungen und Funktionsweise des implementierten Pfandsystems*. Ilmenauer Schriften zur Betriebswirtschaftslehre 2/2011. Ilmenau: Verl. proWiWi, 2011. ISBN: 978-3-940882-27-1. URL: http://hdl.handle.net/10419/55711.

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[6] *Verordnung über die Vermeidung von Verpackungsabfällen (Verpackungsverordnung - VerpackV)*. Bundesanzeiger Verlag. June 1991.

[7] *VerpackV*. 2001.

[8] *VerpackV*.

Glossary

beverage packaging

Predominantly closed packaging for foods of liquid nature intended for consumption as a drink, excluding yogurt and kefir [6, § 3].

ecologically advantageous packaging

Packaging that does now show any significant ecological disadvantages when compared to reusable packaging [**Flanderka/Stroetmann 2009**].

reusable packaging

Packaging intended to be reused for the same purpose after having been used. Characterised by having set up the logistics to take back, clean and refill the packaging. The sole intention or claim to be reused is not valid [6, § 3].