Waste Management Industry from Scratch Using Agile and Modern IT Technologies

Viacheslav Chernikov

Abstract Modern society has a significant impact on ecology, which is why recycling is mandatory for waste management. Existing recycling approaches have many issues and require decades and huge investments to be implemented. This chapter describes a strategy for building the waste management industry from scratch, based on recycling, Agile, DevOps, and modern technologies like cloud, blockchain, mobile, IoT, and AI. The research described below was backed by a group of scientists, entrepreneurs, and activists, and was hosted by the Repnoe School of Effective Communications (Voronezh, Russia). Since 2015, the team has done many different activities and research; it has educated students about recycling; implemented a supply chain for utilizing paper materials from school/college; made social adverts about battery utilization; made a map with recycling points; written guides on recycling at home or shops; analyzed international experience and research; system dynamics modeling; real-world simulation game modeling, business analysis and modeling; software modeling and architecture; and implemented a proof-of-concept. Full research results will be available in the upcoming book, Forming of Waste Management Industry in Modern Russia. Waste management involves many different player roles, and every character has its own goals, behavior patterns, and regulation rules. The first statement behind this study is: 'Waste recycling is more about economics than about ecology.' The final goal of recycling is to reduce the number of non-recycled materials in the overall waste. Businesses should process recyclable materials, and, therefore, the industry must be profitable. Two roles bring working capital—waste producers (payments for utilization) and recycled material buyers (sell goods with such materials on the market), so the government should first focus on the issues associated with these roles.

Keywords Waste management · Recycling · Cloud · Mobile · Blockchain · Agile · DevOps · Azure · Rapid software design

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1 About Research

1.1 Introduction

During the last decade, ecology and waste management have become a hot topic in Russia. The number of issues and requests related to invalid waste management is significantly increasing, and the real percentage of recycled domestic waste is less than 5%. In comparing the situation in Russia with that in other developing and third world countries, we find them similar. Every study starts with a set of questions. Our initial questions are "What is wrong with waste management?" and "How can we fix it?"

In 2015, the author of this chapter headed this research project to find ways to modernize waste management in Voronezh City (an "average city" in Central Russia). The research team consisted of scientists, entrepreneurs, and social activists. The project's initial goal can be described as "find what is wrong with waste management and describe possible solutions." The research team analyzed the experience of using recycling in many developed and developing countries to detect common issues and best practices to adopt them for Russia.

As a final solution of the research, the author suggested a sophisticated software-hardware platform to grow the waste management industry with recycling using Agile, DevOps, cloud, mobile, IoT, AI, and Blockchain technologies. This chapter can be used by specialists working on modernizing and digitizing existing waste management systems as well as growing a waste management industry from scratch. Let us start our deep dive with project history.

Our study aimed to find ways of implementing recycling within current waste management processes in Russia. We used different tools and methods to build a holistic vision of the waste utilization process. This chapter describes a high-level view of the growing waste management industry with recycling based on modern technologies and user feedback. Digital transformation specialists who target the waste management industry can use the models and recommendations provided to upgrade current processes and systems. This study is based on multi-disciplined real-world experiments and research and aims to find a "quick way" of making waste utilization sustainable, structured, and profitable.

1.2 Brief Research History

2015. A group of 13 students from the Repnoe School of Effective Communications in Voronezh, Russia, started looking for models and approaches to reduce domestic waste pollution. The project started by analyzing the current state of waste management in Voronezh. More than 20 local experts, activists, regional government workers, and business players were interviewed. This helped the researchers to get an overview of the problem through the cause-effect system dynamics model. Rough

recyclable materials estimations were also made. "Real-world" waste management business recycling processes were also explored by a group of Voronezh State University students during a simulation game called "Waste Market."

In addition to theoretical research, the team members also did some practical things like educating school/college/university students, collecting paper in school and college, posting social adverts in 200 multi-home apartments about the use of batteries, and more.

The main result of this research phase was understanding that no single local activity can change the situation, due to a lack of infrastructure and recyclable materials supply chains from 'kitchen to secondary usage.' That is why the team focused on the business process to find profitable and sustainable supply chains.

At the end of the year, research results were introduced at the Civic Chamber of the Russian Federation.

2016–2017. The project team prepared an intermediate report to summarize the first research phase results. This report was sent to the Administration of the Voronezh region, but no response followed. The team focused on making requirements for a sophisticated pilot to validate assumptions and gather real data and feedback from citizens and business players.

2018–2019. Cloud platform architecture was introduced as a solution for a unified, scalable, sustainable, and profitable recyclable waste supply chain from the kitchen to secondary usage. To speed up real-world integration and growth, the suggested platform should also educate and motivate all participants. The next sections will cover the cloud platform in detail. Proof-of-concept versions of mobile, cloud and web applications were developed.

1.3 Research Results

During the research phase of 2015–2018, the following scientific results were formalized:

1. A logistics model by the National Research University of Electronic Technology optimized vehicle routes based on real-time events on container occupancy. Software implementation of this logistics model can be used as a cloud service.
2. The cause-effect system dynamics model (by participation-modeling experts Elena Bakhanova and Anna Gladkih) can be used to control the risks and side effects of increasing recyclable materials in supply chains and upgrading the waste utilization process regionally or nationally. As a result, the team got the list of relationships with positive/negative/neutral connections between different aspects of the waste utilization process and its related activities.
3. The simulation game Waste Market (by Dmitry Kavtaradze) was designed to understand real people's behavior in the current (hard recycling with no feedback) and upgraded (easy recycling with feedback) waste utilization processes. As a result, the team built a simulation game model. It told players about the ability

to speed up recyclable materials supply chain growth by providing feedback for citizens (rewards for recyclable waste and proof that 'my waste was recycled') and business workers (increasing high-quality recyclable materials, rewards/penalties for playing fairly/unfairly).

4. Business process models and cloud architecture (by Viacheslav Chernikov) control the waste management industry in the digital age, including apps for citizens, business workers, and government services. This cloud platform should be implemented using lean and agile approaches based on real-world feedback and metrics and by providing maximum value for end-users. The usage of real data on a national level will allow the calculation of the actual number of secondary waste in all existing supply chains. The government should focus on increasing that number while keeping it accessible and profitable.

Based on research results, we formalized the following principles on making the waste management industry in the digital age:

- Accessible: people should be able to recycle without any personal limitations in public places and houses.
- User-Friendly: it should be easy to learn the principles of waste sorting and utilization infrastructure.
- Profitable: all supply chains should bring money to businesses to make the industry attractive for investment.
- Open: high-level data and statistics should be accessible for third party services, citizens, and partners.
- Sustainable: using recyclable materials should not be affected by an international or territorial economics situation.
- Manageable: all business process steps should be controlled by gathering real data, providing reports, and handling semi-automatic issues.
- Unified/Scalable: business processes, tools, and rules should be equal for all territories and also compatible with international agreements.
- Centralized: To find the overall 'X value' (proportion of recycled/not recycled waste), all data and planning should be done by one service. Centralization will allow the government to control the industry and increase the X.

The Cloud Platform should be created with these principles in mind.

2 Improving Business Process

To upgrade the Waste Management Industry (or create it from scratch), it is necessary to start with money-waste transactions and formalizing the business process. This chapter includes a description of the business process and brief actors' behavior.

2.1 Blackbox Model

To simplify the model of the Waste Management Industry, it is enough to focus on economic aspects and the recyclable material supply chain. The high-level blackbox model is shown in Fig. 1.

The base value to control for high-level, industry management should be 'the X value' (T—total waste weight equal to $Y + Z$, Y—recycled waste weight, Z—waste delivered to storehouse):

$$X = Y/(Y + Z)$$

In general, non-recycled waste can be passed through an incinerator, but this process will produce some new waste for utilization and costs a lot. This paper is focused on increasing Y value, but in general, it is possible to reduce the overall T value of produced waste to achieve a 'zero waste' model. The ideal 'zero waste' scenario will have some ways of reusing organic waste and high-cost recyclable materials and will require extra efforts from citizens and government (subsidize non-profitable waste utilization). It is costly to achieve 100% real recycling. For example, very distant territories may consume and produce plastic and it is hard to utilize it the proper way. As a first goal, it is enough to achieve 80% of recycling before investing money or citizen awareness into high-cost business processes.

Keeping a focus on the waste-money supply chain model allowed the team to formalize the process using Business Analysis (International Institute of Business Analysis 2015). The final scheme of the formalized business process is shown in Fig. 2. Current work focused on terms and business roles stated in Russian waste utilization regulatory rules and market terms.

This business process model was used by Dmitry Kavtaradze (scientific advisor of the research project) to create a simulation game that split into two parts: recycling and without recycling. The game was played with 30 university students and showed that citizens are ready for waste sorting if they get feedback from the system. This feedback can be provided as a payback (preferable) for recyclable waste or as 'trust

Fig. 1 Blackbox model of waste utilization business process with recycling, prepared by Viacheslav Chernikov

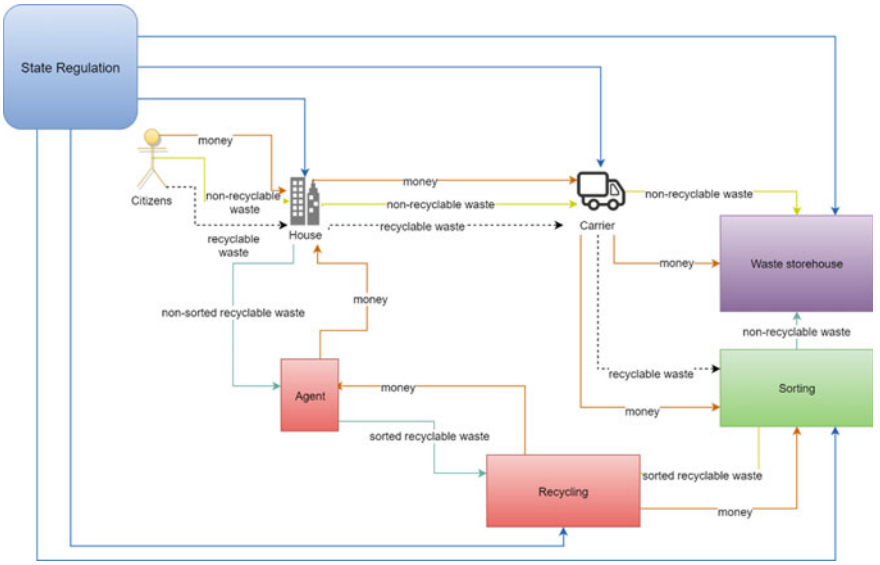

Fig. 2 High-level waste utilization process with recycling by agents. This is based on modifications for the simulation game Waste Market by Dmitry Kavtaradze, initially prepared by Viacheslav Chernikov

signs' (e.g., information that 'my waste was recycled'). Business process schemes without any feedback demotivated players, and they stopped sorting within a short period.

To find a way of improving the Waste Management Industry with the sustainable recycling process, the project team described all business roles involved in waste management:

- State regulators
- Carriers
- Waste producers (citizens and organizations)
- Household management company
- Sorting business
- Recycling business
- Landfill management companies

To describe all these roles within a complex business process of waste utilization, the following behavior aspects were analyzed (but not limited to):

- High-level goals
- Communication tools to deal with the waste utilization process

This chapter does not include behavior algorithms and regulatory rules (specific for Russian Federation) for different roles, but these data will be used to implement a cloud platform for the waste management industry.

2.2 Business Process Roles (Actors/Players)

All noticeable business process actors described below apply complex systems, reaching a maximum set of goals from different players.

State regulator: Current work describes all government and state services as a single actor, or state regulator, within the waste utilization business process.

State regulator goals:

- Control and manage business players to support the sustainable waste utilization process
- Stimulate business players based on real economic aspects
- Get taxes and ecological payments
- Reduce the negative ecology effect of waste utilization
- Reduce the number of complaints from citizens
- Implement the whole business process and regulate it officially

State regulator communication tools meant to deal with waste utilization: legislation, licensing, monitoring, and getting feedback/complaints.

Citizens, Small, and medium waste business producers (offices and other public places). These players are first who bring money (for waste utilization) to the business process.

This player has the following goals:

- Reduce payments for waste utilization
- Get an increased infrastructure and service quality (container cleanness, location, enough count, modern design)

Communication tools to deal with waste utilization:

- Agreement with the household management company (HMC) about the waste utilization service
- Complaints to HMC
- Complaints to state regulators
- Public protests if the state regulator ignores massive complaints

The household management company (HMC). These companies take money from citizens/businesses to support household infrastructure, including waste utilization.

HMC's goals:

- Reduce risks by state regulator checks, followed by an increased number of complaints
- Reduce waste utilization costs

HMCs communication tools to deal with waste utilization:

- Agreement with a waste transportation company (or regional operator)
- Agreement with citizens
- Transfer payments for waste utilization based on agreements
- Implement waste segregation to sell recyclable materials

A waste transportation company. Picks up the waste and transfers it to the sorting company or landfill. It can work with a fixed, floating, or semi-realtime schedule.

Player primary goal: increase profit and overall volume of transport service (rated by money/car hour).

Communication tools to deal with waste utilization:

- Agreements with HMCs, regional operators, and other businesses for waste transportation
- Agreements with landfills
- Optimization of inner business processes
- Licensing by state regulator
- Lobbying and unfair market competition

Recyclable waste resellers are agents who buy recyclable waste from citizens and other waste producers, then sort and sell it for recycling or more extensive resellers. The most valuable and widely used recyclable materials are cellulose, glass, plastic and metals. These types of recyclable materials do not require licensing to be processed by a business company.

Player business goal: increase profit and overall volume of resold recyclable materials.

Agent communication tools to deal with waste utilization:

- Implement infrastructure for recyclable materials processing
- Search for recyclable material sellers (personal or business)

Recycling factories. This is the second player that brings money to the waste management industry (the first one is a waste producer).

Player business goal: increase profit by increasing quality and overall volume of sold recycled materials and by decreasing costs of recycling.

Communication tools to deal with waste utilization:

- Agreements with waste sellers and resellers
- Agreements with buyers

Sorting company. Make sorting of rough materials at any scale and any material type.

Player business goal: increase profit by increasing quality and overall volume of sold recycled materials and by decreasing costs of sorting.

Communication tools to deal with waste utilization:

- Agreements with waste sellers
- Improve sorting with automation
- Load balance agreements with other sorting companies

Landfill management company. These companies are interested in getting as much non-recycled waste as possible using fair and unfair techniques. On the other hand, these companies know the market and can invest in an upgrade to find a profitable place within massive recycling supply chains.

Player goals:

- Increase profit by increasing the overall volume of buried waste
- Maximize the lifetime of landfills

Communication tools to deal with waste utilization:

- Agreement with a transportation company and regional operators
- Unfair play:
  - market monopolization
  - utilization rates manipulation
  - unaccounted waste utilization

Regional operator. This role was introduced in Russia in 2019 with the intent that the regional operator would manage and control the waste utilization process rather than the state regulator. A regional operator is generally a kind of local management company for a specific territory that can be connected to a Cloud platform like local Uber management companies.

3 Waste Management Industry Maturity Levels

Even in developing countries, modern society produces many kinds of waste. Every type requires a dedicated supply chain to utilize waste or recyclable materials. This work focuses on domestic waste.

Implementing domestic waste utilization requires a profitable business process in addition to the existing infrastructure. The necessary infrastructure includes:

- waste bins at the household level
- containers for waste collection from multiple households
- vehicles to transport waste
- landfills as a final destination point for garbage

Optional infrastructure includes recycling infrastructure:

- points/services that buy recyclable waste/commodities
- sorting services
- incinerator services
- businesses that produce raw materials from recyclable waste

Depending on economic aspects of the waste utilization process, such as implementing and supporting infrastructure and making businesses profitable; cultural aspects, such as citizens following the desired behavior patterns; and ecological aspects, such as reducing the impact of waste utilization and mining of raw resources, it is necessary to find a reasonable balance.

For a better understanding of waste utilization processes and specific issues, it is necessary to classify waste management industries with maturity levels based on X

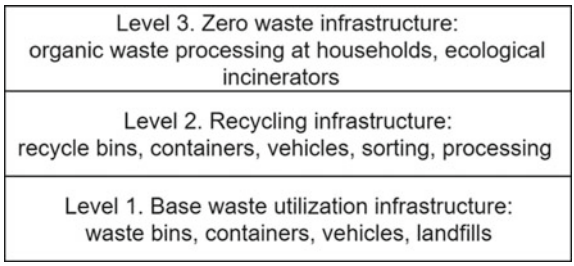

Fig. 3 Waste management industry maturity levels, prepared by Viacheslav Chernikov

value, which is the percentage of recycling. With this classification, it is possible to analyze and compare waste utilization in different territories.

Currently, different territories are at different levels, from no recycling to zero waste (Fig. 3):

Level 1. No recycling (X <= 5%). This level is a basement for the recycling process. First of all, any territory should implement waste utilization with one bin where all types of waste go to one place. Only the strictly necessary infrastructure is required, and the business process can be backed by payments from waste producers (people/businesses pay for waste utilization). Most developing and third-world countries are on that level, and they have many issues, even with essential business processes that should be fixed before implementing recycling.

Level 2. Partial recycling (5% < X <= 60%). As a next step of upgrading waste utilization, most developed countries implemented some ways of recycling. The X value may vary from 10 to 50%, depending on the territory. Waste sorting and optional infrastructure are required for that level. Every person should sort at private/public places to detach the recyclable waste. Different waste classifications exist in different territories, but roughly the sorted recyclable waste has to be precisely sorted before final processing everywhere. Numerous bin and container types make it hard to place, support, and maintain infrastructure. This, in turn, increases business process costs mentally (more time for education and searching for bins/containers for specific waste types) and financially (more containers, vehicles, and actions to utilize). This work suggests using a 2-bins sorting model (recyclable and non-recyclable), which has already been successfully implemented in many territories. On that level, the government should focus on increasing the X value to 50%. Level 2 can be implemented only with correctly working Level 1 processes that handle more than 80% of produced waste and have no protests from citizens and business players.

Level 3. Zero Waste (X > 60%). Most domestic waste is organic by nature and will destroy itself quickly without a negative ecological impact, so it is possible to talk about zero waste mode after reaching an X with 60%. To increase the X value, it is necessary to make extra investments (both financially and mentally). On that level, organic waste should also be recycled to produce manure, bio-gas, or fuel. As a part of the extra utilization step, it is also possible to use high-cost incinerating that meets rigorous ecological requirements. The zero waste mode can only be implemented on top of profitable and sustainable Level 2 recyclable processes.

To select an exact number of bins, it is considered best to use two-bin sorting (recyclable and non-recyclable) as the most straightforward way from mental (education curve), practical (less space and bins), and integrative (easy to install) points of view. These two-bin containers should always be placed together: one with a sign (sticker or stencil for painting) and one regular without any specially added signs. Containers for recyclable waste should be equipped with a cover and the recycle symbol.

4 Fixing Business Process Issues

To make recyclable material supply chains sustainable, profitable, and scalable, it one must specify the most common problems faced by different business process actors as they are defined at various levels. The term "issue" in the current context is used to determine external (infrastructure/environment) or internal (lack of knowledge or intent) barriers that prevent a single person or organization from implementing correct behavior within the required business process. The following tables present a list of the most frequent issues faced during public talks and while interviewing experts and regular citizens (Tables 1, 2 and 3).

All business players making money from recyclable materials (sorting, reselling, reusing) are bound by the global market of recyclable waste, which can be unprofitable in badly structured markets because of its lack of infrastructure and wrong social behaviors as well as the many issues listed above. The government should

Table 1 Issues faced by waste producers (households and organizations), prepared by Viacheslav Chernikov

Level	Issue type	Issue
1	Infrastructure	No functioning waste bins within 5-min walking distance
	Infrastructure	No functioning and free containers within 15-min walking distance
2	Infrastructure	No bins for recyclable materials
	Infrastructure	No containers for recyclable materials
	Motivation	No feedback (with information or money) on successful recycling
3	Infrastructure	High costs of recycling organics on the household level
	Education	Long education curve for household/organization members
	Motivation	Lack of personal motivation to make extra efforts

Table 2 Issues faced by household management and waste transportation companies, prepared by Viacheslav Chernikov

Level	Issue type	Issue
1–3	Infrastructure	Containers are broken
	Infrastructure	Wrong transportation: incorrect vehicle type for the specific waste type or incorrect schedule

Table 3 Issues faced by sorting and reseller (agents) companies, prepared by Viacheslav Chernikov

Level	Issue type	Issue
1	Market	Not enough recyclable materials to be profitable
	Education/Motivation	Poor quality of available recyclable materials
2–3	Education/Motivation	Large % of non-recyclable or hardly recyclable materials inside recycling waste bins
	Market	No access to recyclable material supply chains

take control of markets to make them profitable for recycling businesses at any scale, independent from the global situation.

In general, the state regulator should control all issue resolutions and retrieve as much real data as possible.

There are also some high-level business process issues:

- No simple way to send complaints/feedback and control resolution (communication)
- Hard to find a reliable business partner (communication)
- High costs for transportation and sorting due to poor optimization (market)
- Recycled materials price is higher than equal raw materials price (market)
- Limited market for recycled materials (market)
- No way to balance sorting, transportation, and recycling supply chains between different companies (market)

To fix most of these issues, it is necessary to use a single IT platform that will gather feedback, complaints, and data from businesses and provide optimization, education, motivation, and communication tools.

5 Cloud Platform Architecture and Implementation

Cloud platform architecture, like any other software, should reflect the real world by modeling a complex domain model. The waste management domain model should also reflect different aspects of complex waste utilization and recycling processes, and include tools to motivate and educate people.

5.1 Domain Model

To find a way to make a solution for managing the whole process from citizens to products with recycled materials, other approaches were analyzed including (Kumar et al. 2017; Poon 1997; Aazam et al. 2016; Sharmin and Al-Amin 2016). The approach described in this paper is focused on making a complex chain from the kitchen

(citizens' habits) to final products with recyclable materials. The current vision of software-hardware complex is:

- cloud platform to handle and store all the data, analyze requests and complaints about artificial intelligence, process all transactions and requests/complaints with blockchain, process user activities, provide a backend for user information, analyze collected data to find ways of increasing the overall level of recycled waste
- mobile and web apps for citizens with information, motivation and getting feedbacks/requests/complaints
- mobile and web apps for state workers to handle requests/complaints/accidents and get reports to critical KPIs and information for business players
- mobile, web, and IoT apps for business players to collect tracks of vehicles, key numbers, and transactions, track planning, information about other business players, and interface to communicate with state services and citizens

The main goal of developing a unified cloud platform is the integration of all market players in the waste recycling process across any region or country. Critical areas for which the cloud platform will be created:

- organization, regulation, and optimization of solid-waste recycling business processes across a region or country
- involve citizens and businesses in the process of recycling solid waste
- provide direct communication channels for all market players with rating-based feedbacks

The diagram in Fig. 4 shows the cloud platform's key functional blocks, which are divided into the following domains:

- business process (help businesses to do the job effectively)

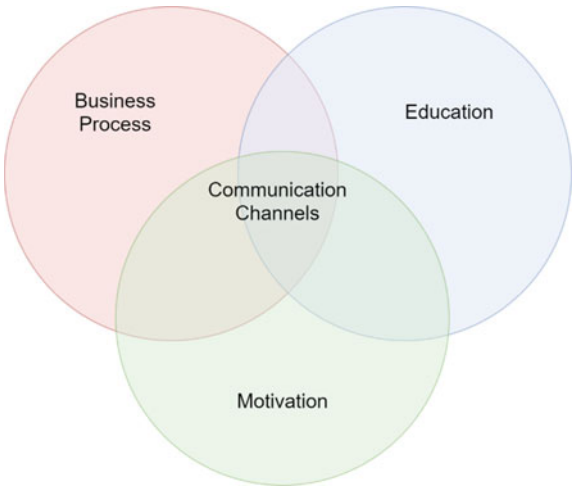

Fig. 4 The domain model of the cloud platform, prepared by Viacheslav Chernikov

- education (provide educational materials for citizens, businesses, and state regulators)
- motivation (provide ratings, feedback, statuses, financial support for market players, citizens, and state services)

Integrating all these blocks into a reliable system requires communication channels. There are two main types of such communication:

1. Messages with requests, complaints, feedback, or ratings by all business process players, including tracking statuses and contract completion, should be based on smart-contracts technology. These messages should be pre-processed with artificial intelligence services to reduce the level of fake, incomplete, and junk messages. Additionally, AI-based text classification will allow automatic responses with possible answers to be provided.
2. Transactions of money and waste between all business process players (citizens, businesses, and the state) based on blockchain technology.

The fundamental concept of the cloud platform is to provide end-users with the most valuable features. That is why Agile (Rothman 2016) and Lean (Ries 2011) approaches should be used together with DevOps practices.

5.2 High-Level Architecture

The cloud platform should consist of many components. Figure 5 shows the high-level solution architecture.

The cloud platform is a set of services for providing different application interfaces (API), collecting and storing data, monitoring critical values, and implementing different communication channels. A collection of user applications (interfaces) should be developed for the following stakeholders:

- citizens: mobile and web applications for learning materials and to provide feedback, including a rating system
- state services: mobile and web application for getting statistics and educating all players; API services for integration with other online services
- business players: mobile application for on-site workers, a web application for back-office tasks, IoT devices for tracking critical values, API services for integrating with on-premises systems
- partners: providing API services for retrieving statistics

The Rapid Software Design approach introduced in (Chernikov 2018a, b; Chernikov et al. 2018) can be used to simplify and speed up the development of mobile and web applications.

Technologies and services that are required to implement cloud and client (web/mobile) applications include but are not limited to:

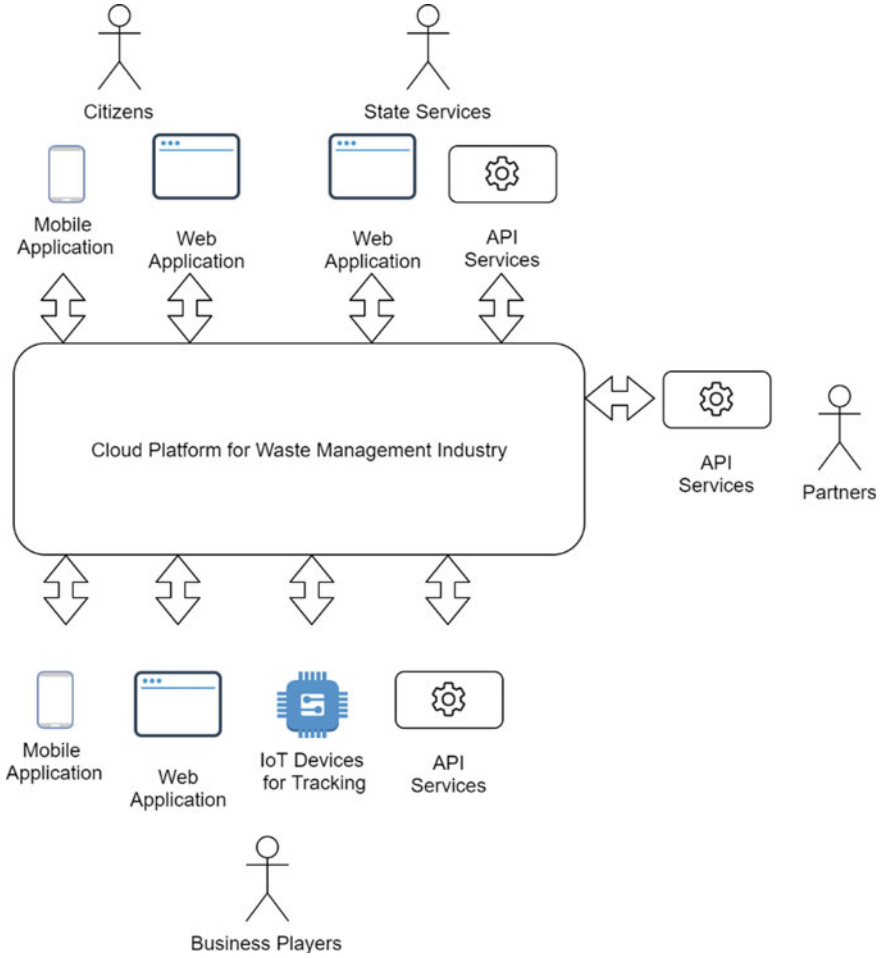

Fig. 5 High-level architecture of the cloud platform for the waste management industry, prepared by Viacheslav Chernikov

- Languages and frameworks: C# (.Net Core, ASP.Net Core, Xamarin.Forms for iOS/Android) and JavaScript (React.js, Node.js)
- Cloud backend: Azure App Services, ASP.Net Core, Azure Functions
- Databases: Azure Cosmos DB, Azure SQL, Azure Blockchain Service
- Storage for unstructured data and files: Azure Storage
- Messaging: Azure Notification Hub, Azure Service Bus
- AI: Azure Cognitive Services (Vision, Search, Decision, Text Analytics), Azure Machine Learning
- IoT: Azure IoT Hub
- Security and User Management: Azure Active Directory, Azure Security Center
- Analytics and Monitoring: Azure Application Insights, Microsoft PowerBI

- DevOps: Azure DevOps, Visual Studio App Center, Azure Dev/Test Lab

Using only two main languages (C# and JavaScript) will allow us to simplify and standardize the development process with a unified number of tools and practices.

To solve business process issues, some modern technologies should be used:

1. Artificial intelligence:
   - Images classification from mobile apps while sending automatic requests for users on the client-side
   - Text requests/feedback classification from mobile and web apps and sending an automatic response for users
2. Internet of things:
   - Vehicle-tracking with smart contracts for automatic detection of issues on the client's side
   - Connected weighing devices with smart contracts support to track the weight of recyclable materials
3. Blockchain:
   - Money-waste transaction tracking should be done in internal currency. In general, the exchange rate can be fixed with 1 INT_CUR = 1 CNTR_CUR, where INT_CUR is internal platform cryptocurrency, CNTR_CUR is a country currency. All loses on currency exchange should be covered by platform fees, percentage from every transaction, and the exact number should be defined for real integration. Also, active citizens can use internal currency as reward points and spent it in internal online shops (sell goods from recycled materials).
   - Tracking complaints/feedback allows state services to get currently issued tickets and automatically find the organization that is responsible for resolving specific issue.

The cloud platform should just be considered as a tool for helping the modern waste management industry with recycling as society moves towards zero-waste status. Contemporary management approaches like Lean and Agile should be used to control and grow the industry. Also, DevOps tools and practices will help to speed up cloud platform development as fast as the real industry will need. User feedback should support platform evolution.

6 Industry Growing with Lean/Agile/DevOps Approaches

To build the waste management industry with the cloud platform in mind, it should be strongly considered that the cloud platform operator (business company) should be profitable and make money on transaction fees. The government should regulate the industry's rules, investments, and cloud platform economics.

To get the first partners and begin to earn first money, it is possible to start with existing low-profit markets. Using IT and social marketing offline will help to structure such niches.

There are some potentially profitable businesses, especially with government support and social marketing:

1. Recyclable waste reselling: Buy sorted recyclable materials from citizens and companies, possibly grow with office buildings and public places, implement two-bin sorting and send waste pickup requests via smartphone when a container is full.
2. Reusable commodity reselling: Buy old furniture, clothes, TVs, fridges, smartphones, and other used goods for low prices and recycle them. Growth is possible by providing selling (your commodities = money for you) or paid (you pay for utilization) waste removal requests.

Due to the high costs of utilizing toxic waste like batteries, it is necessary to stimulate business reselling with different regulation rules (e.g., equip every grocery store with bins for batteries and recyclable materials).

Further improvements to the business process could include logistics optimization with automated vehicle trip planning, decreasing sorting costs with automatic lines, and increasing recyclable materials quality by educating and motivating citizens.

To improve apps and services (online/offline), it is necessary to get feedback and data from real users, including requests, complaints, suggestions, comments, ratings, application usage metrics, and technical and anonymized data.

The cloud platform can be developed step by step, by using a DevOps approach and tools to speed industry growth.

7 Education and Motivation to Speed Industry Growth

Waste recycling became popular within the last 50 years, and it took decades for most countries to integrate waste sorting at the household level. Based on results from European countries and the US, this work suggests using mobile/web apps to educate and motivate citizens to do the sorting at home. Previously, the use of a two-bin (recyclable/non-recyclable) sorting model was recommended to reduce mental complexity and mess within containers, improve accessibility, and make waste sorting user-friendly.

The most active target audience is potentially be young mothers because they care about their children's future, the environment, and cleanliness and have enough free time to learn how to sort waste.

On the other hand, many residents in large modern cities (500,000+ population) already know about waste sorting and recycling from watching TV, using the Internet, or traveling abroad. This should be considered when making educational resources available—most of them should focus on children aged three to nine and elders above 60 who are not familiar with waste sorting.

The cheapest and straightforward way to educate children and elders about the correct way to sort waste is by using smartphone games. Such digital games could have the following features:

- the full game course should include 21 days of regular training with automatic reminders to make a sustainable habit
- the game should consist of several mini-games and have different levels
- the game can also include international methods of waste sorting for those who travel abroad
- a player should be rewarded with points and achievements while learning waste sorting
- the game should also provide ecological advises and interesting facts (e.g., 'one battery can poison one cubic meter of soil').

To simplify the integration of recycling, it is necessary to print stickers with and international 'Recyclable' sign: A5 sized stickers for bins and small stickers to place on recyclable goods. These stickers can be sent automatically to users registered on the cloud platform.

Complete education materials should also include different static content (video, text, presentation) for citizens, activists, state services, and business workers so they can use waste sorting and the cloud platform properly.

Other education topics should rely on real-world practical advice and provide simple ready to use vMeme (Beck and Cowan 2005) phrases about recycling with the following questions:

- What kind of waste is recyclable?
- How to make recycling at home?
- How to join the cloud platform?
- How to get rewards?

There should be a set of simple meme phrases for educational materials and advertising.

To make waste sorting (new citizen behavior!) integration successful and fast, it is strictly necessary to provide communication channels between supply chain actors. Structured communication should include the following message types:

- Issue complaints about business process violation, e.g., a container is broken, or a vehicle delivered recyclable waste to landfill instead of sorting line
- Feedback on business players' work quality based on comments and ranking
- Activist meetups and announcements

Such message senders should get reward points based on smart contracts and activity completion results. These reward points can be equal to or replaced by internal cryptocurrency to simplify their usage and adoption. Also, citizens can reach different levels of platform membership and get a special universal loyalty card with a discount for retail stores (a higher level will lead to more significant discounts).

Motivation is mandatory for making the industry's growth sustainable so that all positive actions should be motivated. Another motivation tool is providing open data

for different territories and households—X value at different scale and structured as a leaderboard.

Using points, achievements/badges, levels, activities, open leaderboards, and real rewards will require some gamification algorithms to be implemented within the cloud platform. In the early stage of cloud tools integration in the real world, it is recommended to implement offline contests and activities (e.g., one-day training of waste sorting at a specific territory) with free stickers, toys, and other prizes.

On the other hand, it is necessary to stimulate fair play with clear rules. Companies with wicked ranks should be blocked at the platform, and all issues (especially unfixed) should lead to penalties (e.g., a person who sent an approved issue will get some cryptocurrency from the company that responded to that issue).

Using communication channels, motivation, and gamification will increase people's involvement and speed up the growing waste management industry to Levels 2 and 3.

8 Results

As mentioned previously, the current research project was started in 2015 with the questions, 'What is wrong with waste management?' and 'How can we fix it?' To summarize the answer, it is possible to state that the 'key of most issues is lack of or invalid communication between business process actors.' Communication means all types of information exchange between business process actors such as money transactions, actions within the business process, real-world data, texts, photos, video. To structure these information channels, it is necessary to implement a cloud platform that should be backed and controlled by the government as a stable industry. So, our research came to this answer, 'Communication within the business process is outdated and should be upgraded with modern technologies to scale recycling.'

Current project scientific results include the following models:

1. Logistics model by the National Research University of Electronic Technology
2. Cause-effect system dynamics model by participation modeling experts Elena Bakhanova and Anna Gladkih
3. Simulation game model by Dmitry Kavtaradze
4. Business process models and cloud platform architecture by Viacheslav Chernikov

Current project state:

- scientific research finished and described in this paper
- proof-of-concept implementation with prototypes of mobile and web applications, cloud backend, Agile, DevOps, C#/.Net, Azure
- implementation of landing page http://яразделяю.рф (http://xn–80aidgwz7hbg.xn–p1ai), stickers, marketing materials

- a base assumption about the profitability of a cloud platform on a large scale validated by business experts—IT-backed business to handle supply chain of recyclable materials 'from office to reselling' can process orders and transactions like Uber
- sharing scientific results in several articles and public talks/presentations
- searching for markets with a possible 'Shut up and take my money!' situation (a phrase from cartoon series, *Futurama*, about a fascinating and attractive product) and starting a pilot to handle recyclable material supply chains 'from office to reselling,' to get real economics numbers and profitability on a small scale for extrapolation.

9 Discussion

Current work describes how to upgrade waste management with modern technologies and provide unified 'Uber-style' applications for different types of users and businesses involved in the waste management industry. Significantly, this work is focused on implementing structured communication channels between different user roles rather than making 'smart recyclable bins' and 'continuing to monitor" solutions.

This paper also introduced the maturity levels of waste management based on 'X value' and existing infrastructure. This work strongly suggests two-bin sorting on behalf of education and motivation scenarios in order to speed up the movement toward zero-waste.

Known limitations of that work include the necessity of validation for education and motivation aspects to find the ready-to-use solutions. Also, it is necessary to mention that most business players within the waste management industry, especially in developing and third-world territories, have deficient management and IT maturity levels that can slow down industry growth. That is why future research should be focused on obtaining real numbers and feedback by real users so as to confirm the assumptions related to the education and motivation of users.

10 Conclusion

This article contains a high-level vision of the cloud platform that should be used for modernizing the waste management industry or implementing it from scratch. In order to develop a sustainable business process of waste management, it is necessary to add education and motivation domains to the cloud platform and implement the whole system parallel to offline activities.

The cloud platform should provide dedicated user interfaces for different types of users and focus on key X-values—the ratio between the recycled/not recycled solid waste.

This paper describes the set of approaches that can be combined to build sustainable and scalable recycling processes on the way to zero waste and low ecology footprint with the current form of consumption.

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