

The Theoretical Basis and Practical Usage of the Simulation for Creating IT Solutions for Data Management Systems

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Abstract – This paper presents results of the research concerning usage of simulation for creating IT solutions corresponding to the Data-And-Rules-Saved-In-Resource (DARSIR) concept of designing data management systems while using the Radio Frequency Identification (RFID) technology. During research typical approaches for creation of simulation tools were studied. DARSIR simulation tool was developed and a practical experiment has been conducted in order to get an IT solution in the form of multiple RPML documents.

Keywords: Data-And-Rules-Saved-In-Resource concept, Radio Frequency Identification, Resource Physical Markup Language, simulation, XML

I. INTRODUCTION

Nowadays, creation of IT solutions is a very laborious process. Many information technology specialists are trying to find an easy way to simplify this process. The authors of this paper are also working in this direction and already proposed an alternative concept of designing data management systems [1]. The concept is called Data-And-Rules-Saved-In-Resource (DARSIR). Implementation of this concept for solving practical tasks was studied through practical examples in the following articles: “Monitoring and Management of Traffic” [2] and “Smart Laundry” [3]. Even though this concept can be used with different technologies (Radio Frequency Identification (RFID), WiFi, WiMax, Barcode, etc.), in previous and current works, the RFID technology based concept of designing data management systems was chosen for the research analysis.

Historically, RFID technology came to replace the Barcode technology (in more detail described in [4], [5]). Many business applications have been developed, in which Barcode technology was used (for example Enterprise Resource Planning System, Warehouse Management System, Manufacturing Execution System). Therefore, while changing from Barcode to RFID, vendors firstly were integrating RFID technology work modules to the existing software. Until now, a lot of business applications can work with Barcode technology and also with RFID technology simultaneously. Using this strategy, it is possible to lower expenses of introduction of RFID technology. But not all RFID technology advantages were utilized (especially the data storage availability in RFID tags).

A gradual transition to RFID-only technology based solutions is carried out now. In RFID industry EPCglobal standards are used as de-facto standards. EPCglobal is a

consortium of industry leaders like Wal-Mart, Cisco Hewlett-Packard etc. [6]. There are as many different strategies possible for using RFID, as there are companies producing RFID solutions [6] – [9]. A lot of companies use EPCglobal standards, but sometimes they use different terminology and data exchange standards (IBM, for example, uses not only XML but also its own data exchange standard MQ) [2]. SAP uses its own architecture which is a built-in SAP application. Some researchers are also developing lightweight RFID middleware (for example SmartRF [10], IBM Lightweight RFID bus framework [11]), which are characterized by simple architecture and usage, based on small businesses.

One of the methods for simple creation of IT solutions is the usage of simulation tools. Nevertheless, when creating IT solutions, usually programming tools are being used. This paper proposes creating IT solution directly via creating a simulation. One of the methods to do that is to create a simulation tool, which is adapted to a specific data management system. This paper demonstrates the idea using the DARSIR concept, introduced in earlier research by the authors (see [1-3]), as an alternative concept for data management system creation.

The remainder of this paper is organized as follows. Section II examines Visual Interactive Simulation (VIS). Section III examines RFID technology. The basic components of DARSIR concept are described in the fourth section. Working principles of the IT solution are described in the fifth section. In the sixth section, data storage type, attributes, and rules are described. In the seventh section, an experiment of organizing regulation of temperature inside a room is described. Finally, the last sections propose possible variations of the simulation creation from an IT solution and give recommendations on using the proposed approach.

II. VISUAL INTERACTIVE SIMULATION

For this research, Visual Interactive Simulation (VIS) was chosen, the main principles of which were generalized in [12] in 1987. VIS was chosen as one of progressive simulation tendencies. This can be seen from research of using Visual Interactive (VI) models in [13], [14].

VIS is the integration of data visualization tools and interactive steering resources. Therefore, the user can observe intermediate results and interact with the model during the experiment itself. Model parameters and variables, as well as visual presentation aids, may be modified during the

experiment, with an immediate impact in the simulation process [15].

In 1990 in [16] three classes of interaction and visualization were defined: post-processing, tracking, and steering.

Definition of each of the classes of interaction and visualization are as follows:

- *Post-processing* – simulation environment, during work of which users are not able to observe and manage the experiment. Experiment work result is stored in the form of output data in the database. After that the data is extracted from database using a visual tool. Main usage is post-processing analysis. An example is the CINEMA system [17].
- *Tracking* – simulation environment, during work of which intermediate results could be observed. The user can observe experiment using different visualization instruments: animation, diagrams, multiple windows with intermediate states, time transition during experiment etc. Usually the user defines time, during which experiment is carried out; he also defines variables, which he would like to see. Simulation model change is the main limit. An example is the GPVSS system [18].
- *Steering* – simulation environment, which allows the user to upgrade simulation model during the experiment. This is the main difference from post-processing and tracking classes. User-Centered Paradigm for interactive simulation [19] could be shown as an example. Usually steering simulation environment is called Visual Interactive Simulation environment.

In our case, when we use simulation for developing an IT solution, we have to use steering simulation environment. In this case, we obtain the environment, which allows maximally simple and fast IT solution creation and upgrade.

III. RFID TECHNOLOGY

Radio Frequency Identification (RFID) is an automatic identification method, which relies on data storing and remote retrieving with the use of devices called RFID tags. It is possible to place RFID tag in a physical object, embedding the tag in it, or to construct interaction with other physical objects (for example sensors).

This paper is not intended to provide detailed information about RFID technology. For detailed information see [4].

The following are RFID technology basic component definitions, as they are used later in this paper:

- *Electronic Product Code (EPC)* – is an identification scheme that can uniquely identify a physical object. In RFID technology context it is a 96-bit number which contains the information: header, manager number, object class and serial number [4].
- *Physical Markup Language (PML)* – the format modification of XML. It provides a format of saving and exchanging data about physical objects and is described in [20] as “a simple, general language for describing physical objects for use in monitoring and control of a physical environment – particularly through the Internet.

Applications include inventory tracking, automatic transaction, supply chain management, machine control and object-to-object communication.”

IV. THE DARSIR CONCEPT

DARSIR concept [2] – is the concept of designing data management system the basis of which is the idea of refusing to use other sources (such as database) and the decision to save the information (attributes and rules) to a physical object (resource).

DARSIR concept is based on the following basic components:

- *DARSIR resource* – any object of the living or lifeless nature which is involved in working process of information system. The information of a concrete resource and its interrelationship with other objects (or types of objects) must be stored in this resource.
- *Resource Physical Markup Language (RPML)* – XML-like language that is developed specially for DARSIR concept. It is a new modification of PML.
- *RPML document* – a collection of DARSIR resource data (attributes and rules) represented in Resource Physical Markup Language (RPML) that physically is stored in the resource itself.
- *DARSIR project* – pack of resources (RPML documents) for concrete task implementation.

Basic element of this technology is RFID tag, it is an object that can be attached to or incorporated into a product, animal, or person for the purpose of identification using radio waves. It is possible to store up to several megabytes of data in each RFID tag. Such capacity allows uniting the list of attributes (data) with functionality (rules) in DARSIR resource. RFID tag complies with all sections of DARSIR resource and gives the opportunity to use DARSIR concept based on RFID technology.

V. WORKING PRINCIPLES OF THE IT SOLUTION AND SIMULATION

First step of simulation usage for solution creation is defining working principles of concept and ways of simulation usage in creation of IT solution.

The main working element of DARSIR concept based on RFID technology is RFID reader. In our case RFID reader has a built-in embedded system that loads to and carries out rules from resource (RFID tags). To load rules from resources (RFID tags), they must be located in RFID reader working zone. If RFID readers are connected in a network of RFID readers, RFID readers carry out resource (RFID tag) information (attributes and rules) exchange.

Resources (RFID tags) are important for IT solution and simulation because to create a working process it is necessary to change information (attributes and rules) only in resources (in RFID tags). Other elements of the working process (such as RFID reader) usually do not require any modifications. To use the simulation for creating an IT solution, it is required that sufficient information (each resource attributes and rules) is entered.

VI. STORED DATA TYPES

Next, the structure of the stored information in simulation should be defined. From the previous chapters it is known, that all information that can be changed, is stored in resources (RFID tags). And all information that is needed in an IT solution must be edited by the customer in a simulation scheme. It is not possible to create a finished IT solution if this condition is not fulfilled.

The next step is to describe format of storing information in this concept. In the DARSIR concept description [1], a new modification of PML was presented – the RPML. Further in this document examples in RPML are given, but the places, where syntax coincides with the official version of PML, are not separately described (they can be found in the official page [20]).

To create an IT solution, for each element it is necessary to create RPML document from finished simulation model and load it in an appropriate resource (RFID tag). RPML documents have attributes and rules. Main types of attributes and rules, and kinds of stored information are defined in the following sections.

A. Attributes

Each resource has unique features, but it is possible to emphasize some standard kinds of such features:

- Physical – any resource possesses physical properties, it is possible to determine from what material the resource is made, the length of the resource, etc.
- Sensors – the resource can have built-in sensors (such as thermometer, hydrometer); the current value of a sensor is stored in the resource as an attribute.
- Entity – the resource can have its owner (it can be a person, an organization, a country, etc.), so here such parameters as a name of the owner, the name of the organization, the address, etc. are registered.
- Location – the coordinates of a resource. Concerning the reading device they can be in 2D (X and Y), also in 3D (X, Y and Z) coordinates.
- Configuration – resource can consist of another resources (e.g. bulk shipment), here the unique numbers of other resources can be listed.
- History – parameters of any kind, that have a timing component, when these parameters have been fixed. It is very important to remember that memory of a resource is limited and consequently it is necessary to limit final number of possible records.
- Variables – any program can be stored in a resource, and variables are necessary for its work. There are standard types of variables (such as Integer, String, Date, etc.), and also nonstandard (such as arrays, defined in PML).

Depending on defined tasks and on variants of their solution, other kinds of features are also possible. It should also be noted that there exist tags which communicate with the carrier. The typical example of this kind of a tag is a sensor. For example, the thermal sensor control can write a current condition of temperature into a tag. Also any mechanism (being the carrier of tags) can write the information onto it.

For example, the printer can write the working condition of itself (such as “printing”, “on”, “off”, “waiting”, “error” etc.) on the tags.

Some standard attributes can be used in simulation as static data, such as physical, entity. But some standard attributes can be changed in simulation process, such as sensors, location, configuration, history and variables.

B. Rules

In simulation, rules can be created by simulation languages. This section defines the format of how simulation rules have to be converted for creation of an IT solution.

The ideology is similar to usual programming languages and analogical examples in programming language C++ are specified for better understanding of the chapter. In a resource the rules are presented as the program, in the form of XML.

The executable block of the program, called “task”, can be defined as a procedure. The very first executable task in a resource is called “main”. In the task itself, several kinds of operations can be applied:

- Executable – actions which can execute resources. Typical actions: to include, to switch off, to start, etc.
- Boolean – the Boolean operators, consisting of condition and task, which will be executed (or on the contrary not executed) if condition is true.
- Predefined – the built-in operators, which are predetermined by the system (for example, for definition of distance between two resources, operation “Locate” is used).

The syntax of the task:

```
<task label = "procedure" variable="value">
  ..
  <return type = "variable">value</return>
</task>
```

With the tag “task” the working block is defined, where the name of the task (procedure) should be defined. Then the names of variables with their values are listed. The authors want to emphasize that it is necessary to define these variables, which are transferred into “task”. Inside of the procedure there are operations. If there is a necessity to return any values, then the type of procedure (type) or name (variable) or returned value (value) is defined. If this task is used as a condition in verifying operation, then the last value in the last tag “return” is considered.

The syntax of the executable operation:

```
<msr label = "resource.command">text</msr>
```

“Msr” operator means that a command should be run; “resource” – resource, where command should be run, if it isn't defined, command should be run in the resource where this executable operation is running; “command” is command that should be run; “text” is text, which will be shown in log files.

The syntax of the conditional construct:

```
<if label = "name" condition="condition">
  <true>..</true>
  <false>..</false>
</if>
```

By means of tag “if” it is possible to define a condition. Conditions of comparison are set by an alphabetic combination: EQ (=), GT (>), LT (<), GE (=>), LE (<=), NE (<>). If the condition is true, then the working block, which is located in the tag “true” should be executed. Otherwise, the block of the tag “false” is executed. Verification operation has a name, with which it is possible to identify verification operation (name). If tags “true” and “false” don’t exist, it is considered as tag “true”.

VII. EXPERIMENT

So far, the theoretical basis of the various aspects of simulation usage for creation of an IT solution with DARSIR concept was briefly described.

To clarify the practical usage of the simulation for creating an IT solution with DARSIR concept, a concrete problem, its solution in DARSIR project, and description of project creation in DARSIR simulation tool are described.

The subject of the experiment is regulating temperature inside a room where initial data are the conditioner (downturn of temperature), the heater (rise of temperature) and the thermo sensor (capable to take temperature).

A. DARSIR project

Working scheme of DARSIR project for regulating temperature inside a room consists of three resources: conditioner, heater and thermo sensor. Further there is a definition of minimal amount of attributes and rules to provide implementation of the given task.

First of all, the attributes that can be used for solving the problem should be defined. In thermo sensor, there is an already build-in attribute “Temperature”, which is changed on demand of attributes from the environment. Also, it is required to add two more attributes – “Min” (admissible minimum) and “Max” (admissible maximum), which are required for temperature level regulation in the gap from admissible minimum to admissible maximum. One sensor type attribute and two variable type attributes are defined.

In RPML it looks as:

```
<mat label = "thermosensor">
  <extrude type = "Temperature"> 0 </extrude>
  <integer label = "Min"> 20 </integer>
  <integer label = "Max"> 21 </integer>
</mat>
```

The next step is definition of accessible executable operations. The conditioner and the heater have two executable operations “On” and “Off” which allow switching on and off these devices.

There will be a control block (or in other words – working algorithm) in the thermo sensor:

- If value of the parameter “Temperature” is greater than value of the parameter “Max” then the heater is switched off and the conditioner is switched on.
- If value of the parameter “Temperature” is less than value of the parameter “Min” then the conditioner is switched off and the heater is switched on.

In RPML it looks as:

```
<task label = "main">
<if label = "Hot" condition = "Temperature GT
Max">
  <msr label = "Heater.Off"></msr>
  <msr label = "Conditioner.On"></msr>
</if>
<if label = "Cold" condition = "Temperature LT
Min">
  <msr label = "Conditioner.Off"></msr>
  <msr label = "Heater.On"></msr>
</if>
</task>
```

B. DARSIR simulation tool

The next stage is DARSIR project creation in DARSIR simulation tool. DARSIR simulation tool is software (see in Fig. 2), which enables to create simulations based on DARSIR concept. The result of this simulation can be imported as multiple RPML documents (one document for each resource).

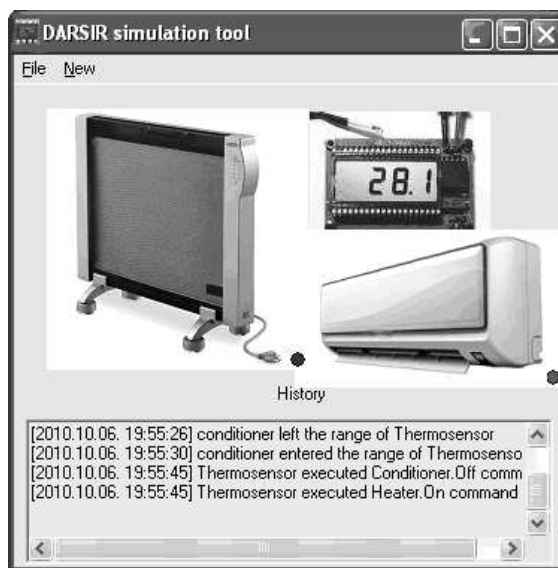


Fig. 1. Main window of DARSIR simulation tool; in this situation project “regulation of temperature inside a room” is opened

In the previous chapter, the steps of RPML document creation for each resource were shown. Then via graphical interface of DARSIR simulation tool, DARSIR project was created in this application to run the simulation.

DARSIR simulation tool added additional attributes that are of attribute types Physical and Location. Description of the thermo sensor resource can be seen in Fig. 2.

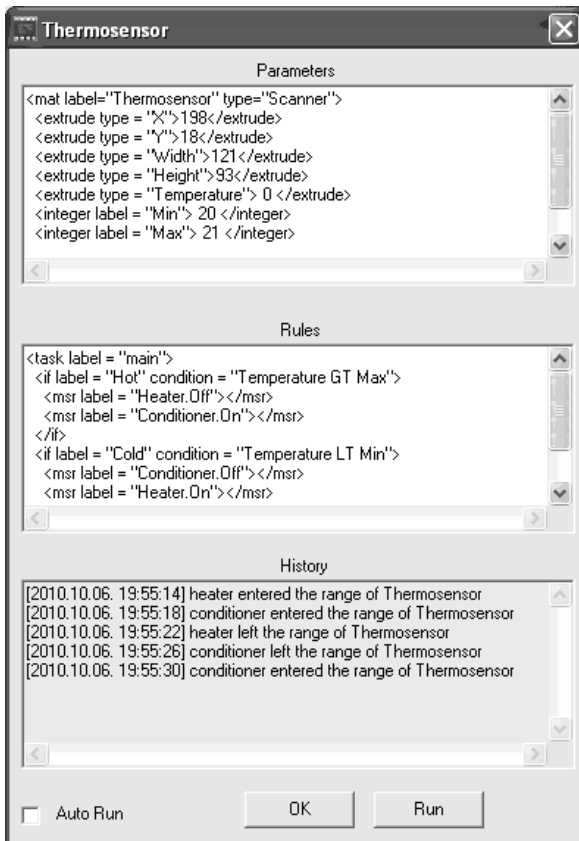


Fig. 2. DARSIR simulation tool window describing work of “Thermosensor” resource

After creation of the project, simulation was done, which involved changing attribute “Temperature” in resource “Thermosensor” and monitoring turning on/off of “Conditioner” and “Heater” resources.

The authors ensured that the rule of working and task of regulating temperature inside a room are correct. The result of this simulation can be imported as multiple RPML documents (one document for each resource). RPML document after this can be loaded to RFID tags to create an IT solution.

In simulation, it is important to define correct executable actions, so they can execute resources needed. If simulation has any mistakes in names, it means that in transformation process from simulation to an IT solution this mistake must be fixed. After that it is necessary to implement a mechanism for name consistency checking.

VIII. POSSIBLE VARIANTS OF THE SIMULATION CREATION FROM IT SOLUTION

Sometimes customers have IT solution ready and need to make some changes for this solution with simulation usage. For this functionality with simulation usage, the following scenarios are possible:

- IT solution created by DARSIR concept – all attributes and rules from resources should be transferred to the simulation scheme;
- IT solution with all elements with built-in RFID tags – some part of attributes should be loaded in the simulation scheme, as physical (if RFID identification owner type

description is present), sensors (if present), entity (if present in RFID tag), location (possibly defined by RFID readers), configuration (possibly defined by RFID readers), etc.

- IT solution with all elements without built-in RFID tags – in this situation the first step is to build in RFID readers. Some part of attributes should be loaded in the simulation scheme (but usually less than in the previous one), as physical (if RFID identification owner type description is present), sensors (if present), location (possibly defined by RFID readers), configuration (possibly defined by RFID readers) etc.

IX. EXPEDIENCY OF USING PROPOSED APPROACH

In Chapter VII a practical usage experiment of proposed approach was conducted. For conduction of the experiment in DARSIR simulation tool, IT solution creation module was built in. This module creates the IT solution in the form of multiple RPML documents. The simulation tool works on the basis of DARSIR concept and every concrete resource is represented in the form of RPML document.

There are many simulation tools developed [12-19]. When adopting an already existing simulation tool, it is necessary to create a transformation module, which converts simulation into an IT solution. Therefore, for each combination of a simulation tool and data management system additional research should be conducted. For each concrete research it is necessary to define the set of data and rules. These data and rules should then be added to the simulation tool in order to provide an IT solution. Therefore, the usage expediency of proposed approach is to be defined for each concrete case individually.

Expediency is to be defined as follows:

- Simulation tool should repeat working principles of the data management system (as shown in this research practical experiment);
- Simulation specification level is sufficient for describing full work of the IT solution;
- Simulation tool allows adding additional data and rule types;
- Simulation tool is steering simulation environment.

CONCLUSION

In this paper, one of the approaches to simplifying the process of creating IT solutions is studied – creating IT solutions directly from simulations. When creating IT solutions, usually programming tools are used. Testing of IT solutions is usually made in real conditions. By using simulation tools, optimal solutions can be found before creating an IT solution. In this research, possibility of speeding-up the development process was studied. When creating the simulation, the final IT solution is created.

To show feasibility of the proposed approach, the task for the solution was defined. The task of the conducted experiment was to organize regulation of temperature inside a room. Practical implementation was made using DARSIR concept on the basis of RFID technology. For this

environment, a DARSIR simulation tool was developed incorporating a module for creating an IT solution in the form of multiple RPML documents. As a result, basic components of DARSIR concept, data storage type, attributes, rules, etc. were described and working principles of the IT solution and simulation were shown.

While working on the development of IT solutions, it is recommended to define expediency for each concrete case individually. In case when a simulation tool is developed specifically for the concrete data management system, various aspects discussed in this document can be used as a practical guide. On the other hand, if an already existing simulation tool is to be adapted, it will be necessary to create a transformation module which converts simulation into an IT solution. Therefore, additional research should be conducted for each combination of a simulation tool and data management system.

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Vadims Žuravļovs, Eleonora Latīševa, Vadims Kairiņš. Simulācijas teorētiskais pamats un praktiskā pielietojšana datu vadības sistēmu IT risinājumu veidošanai

Pēdējā laikā viens no svarīgiem uzdevumiem, kas jārisina daudziem informācijas tehnoloģiju speciālistiem ir vienkāršu ceļu meklēšana IT risinājumu izveidošanai. Eksistē dažādas tehnoloģijas un datu vadības sistēmu projektēšanas koncepcijas, kuras var izmantot IT risinājumu izveidošanai, neizmantojot programmēšanu. Autori piedāvā alternatīvu pieeju IT risinājumu izveidošanai – simulācijas izmantošana. Pētījuma pamatā ir izvēlēta Radiofrekvences identifikācijas (Radio Frequency Identification, RFID) tehnoloģija. RFID ir automātiska identifikācijas metode, kas balstās uz datu glabāšanu un attālinātu datu nolasīšanu, izmantojot ierīces, kas tiek sauktas par RFID birkām. RFID birka var būt novietota uz fiziska objekta, iebūvēta fiziskā objektā, kā arī tā var veidot saiti ar citiem fiziskiem objektiem. Viena no alternatīvām datu vadības sistēmu projektēšanas koncepcijām ir Dati-Un-Likumi-Glabājās-Resursā (Data-And-Rules-Saved-In-Resource, DARSIR), kuru ir iespējams izmantot ar RFID tehnoloģiju. Galvenie pamati šai koncepcijai ir universālums un elastīgums, kā arī nav nepieciešams izmantot ārējo informācijas glabāšanas avotu (piem., datubāzi), jo visa informācija (atribūti un likumi) tiek glabāta RFID birkās. DARSIR konceptuālais datu glabāšanas tips atvieglo pāriešanu no simulācijas shēmas uz IT risinājumu. Darbā tiek apskatīti dažādi simulācijas veidi un pētījuma uzdevuma risinājumam tiek

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izvēlēta Vizuāla Interaktīvā Simulācija (Visual Interactive Simulation, VIS). Rakstā ir dots RFID tehnoloģijas apskats, DARSIR koncepcijas pamatkomponenti, datu glabāšanas tips, atribūti, nolikumi, IT risinājuma un simulācijas darbības principi. Pētījuma laikā ir analizētas tipiskās pieejas simulācijas rīku veidošanai. Ir izstrādāts un praktiski pielietots eksperimentā DARSIR simulācijas rīks. Eksperiments tika veikts, lai saņemtu IT risinājumu dažādu RPML dokumentu veidā. Šajā darbā tiek piedāvāti dažādi simulācijas izmantošanas aspekti risinājumu izveidošanai. Beigās tiek definēti secinājumi un iespējamie uzdevumi nākamajiem pētījumiem.

Вадим Журавлев, Элеонора Латышева, Вадим Кайриш. Теоретическое обоснование и практическое применение симуляции для создания ИТ решений для систем управления данными

В последнее время одно из важных заданий, которое пытаются решить многие специалисты информационных технологий - это поиск простых путей для создания новых ИТ решений. Существуют разные технологии и концепции проектирования систем управления данными, которые могут быть использованы для создания новых решений без использования разработки программного обеспечения. Авторы предложили альтернативный подход для создания ИТ решений – использование симуляции. Для данного исследования была выбрана технология радиочастотной идентификации (англ. Radio Frequency Identification, RFID) . RFID – это автоматический метод идентификации, который основывается на хранении и извлечении данных на расстоянии при помощи устройств, которые называются RFID метки. RFID метка может быть размещена в физическом объекте, встроена в физический объект, а также может взаимодействовать с другими физическими объектами. Одна из концепций моделирования систем управления данными – концепция Данные-И-Правила-Хранятся-В-Ресурсе (англ. Data-And-Rules-Saved-In-Resource, DARSIR), которая может быть использована с технологией RFID. Главные особенности этой концепции - универсальность, эластичность, отсутствие необходимости использования внешних источников хранения информации (например, базы данных), так как вся информация (атрибуты и правила) хранится в RFID метках. Этот концептуальный тип хранения данных облегчает переход от схемы симуляции к ИТ решению. В этой работе рассмотрены различные виды симуляций. Для решения задачи исследования была выбрана Визуальная Интерактивная Симуляция (англ. Visual Interactive Simulation, VIS). В исследовании представлены описание RFID технологии, основные компоненты DARSIR концепции, вид хранения данных, атрибуты, правила, принципы работы ИТ решения и симуляции и др. Во время исследования были изучены типичные подходы для разработки программ симуляции, разработана и применена в эксперименте программа симуляции DARSIR. Эксперимент был проведен, чтобы получить ИТ решение в виде нескольких RPML документов. В работе представлены различные аспекты использования симуляции для создания решений, выводы и возможные направления последующих исследований.