ANALYSIS OF AUTOMATIC IDENTIFICATION AND DATA CAPTURE SYSTEMS USE IN LOGISTICS

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Abstract

Automatic identification and data capture (AIDC) systems became common device for society. This technology can be found in all possible human activities, like material flow systems, libraries, logistic, industry or basically everywhere is required items tracking throughout items movement. Automatic identification provides accurately information about specific items storage. This information can be used for control functions relevant to the specific items as well as for automatically evaluation item's conditions and decision making if it's needed.

This paper explores all systems of AIDC, from historical ones to nowadays technologies, provides basic comparison between most used systems.

1. Introduction

AIDC technologies refer to methods of recognizing objects, collecting data about them and utilize these data. These systems are commonly referred as "Auto-ID systems or Automatic Data Capture. This chapter describes evolution of AIDC technologies from the beginning to current modern systems.

1.1. History of AIDC

Procedures of automatic identification a data capture became in recent years very popular. True is, AICS technology have a long history. [7] First research in AIDC technology was in 1950s, when two researchers at IBM awarded first patent for automatic identification in year 1952. After twenty years of research and evolution in 1970s U.S. grocery allowed deploy of barcode technology in supermarkets across the country. Task was simple: reduce labor costs, improve checking speed of tracking sales and inventory. All of this leaded in 1973's born of Universal Product Code (UPC) – barcode, which defined specific product. Because of slow implementing UPC symbols on packaging, grow of the bar coding was also slow. Big moment came in 1981, when U.S government initiated program which required that all products sold to the U.S military be marked with barcode. This condition start the revolution in supply chain management: in 1978 only 1 % of grocery stores had barcode scanners, in 1984 it was 33%.

This revolution brought some evolution of barcode. At first, UPC codes had only 12 numerical digits. No letters, no characters nor other content, which is common nowadays (like special digits @,&, etc.). In 1984 was created first "SMART CARD", like prepaid

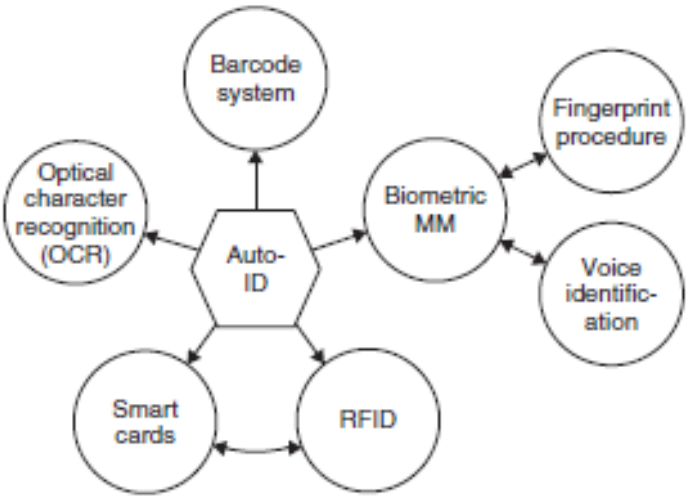
telephone cards, which is considered as new generation of barcode. First Smart cards contained barcode wrote on in to be readable with common barcode scanner. A Smart card is an electronic data storage system with additional computing capacity supplied with energy. These cards are placed in a reader, communication between card and reader is working via galvanic connection using bidirectional serial interface. In comparison to barcode technology, purchase of smart labels is more expensive, technological more demanding and more difficult to implementation. The primary advantage of smart labels is security. Data on the labels can be protected against undesired access and manipulation. Smart card services all information simpler, faster and chipper. For this reasons in 1992 were over 200 million smart cards used worldwide. [4]

RFID (Radio frequency identification) systems are very similar to Smart Card technology. Like them, data are stored in electronic data-carrying device. Unlike Smart Cards, RFID use for data-exchange between readers and data-carrying device magnetic (or electromagnetic) fields (unlike galvanic connection). RFID technology provides even better visibility in material flow; movements can be done more easily and quicker than with smart cards or barcodes. Data reading is faster than smart cards and can be done from greater distance.

1.2. Current AIDC systems

In chapter above was described evolution of AIDC technology from barcodes to RFID. That does not mean, that barcodes and smart cards are not using nowadays. Barcodes are using in groceries, libraries or material flow all over the world. Smart cards are using as contactless tickets for public transport. Barcodes are currently most used AIDC technology all over the world, RFID technology have the potential to replace barcodes in the future. In Auto-ID systems belong other technologies, then these mentioned above. For most used AIDC technologies see Figure 1.

Figure 1: *Overview of the most important auto-ID precedures*



Source: Finkenzaller 2010 [4]

Except barcodes, smart cards and RFID there are OCR (optical character recognition) and Biometric MM. OCR is technology of mechanical or technical digitalization of images or texts (handwritten or printed). After this method handwritten text can be used like common computer text. OCR can recognize single character or whole sentence, depending on OCR typ. However OCR technology is not universally applicable. In comparison with other ID systems, OCR is more expensive and required complicated (and also more expensive) readers.

Biometric (Model Measurement) is defined as the science focusing on counting a measurement procedures in living beings. It comes from single premise: every creature (including human being) is unique. Biometric can use many options of identification, like fingerprint voice analysis, signature, and face recognition.

2. Barcodes

The oldest technology of AIDC systems – barcodes – is nowadays worldwide used. The biggest reason is the price of this technology. [12]

2.1. Background

Originally barcodes were specific series of vertical, black and white stripes. First barcodes contained only numerical characters. As time goes by, barcodes evolved in many variants. Nowadays barcodes can even consist from parallel stripes; modern scanners can read barcodes from most of color papers. Readability of barcodes depends on scanners used for reading. Distance for barcode reading is maximal 0,5 meters, which mean, that standards scanners have to read barcodes in this distance. However, one of scanners parameter is, on which distance can read barcode (alike number of scans per second, supported barcodes, scan resolution etc.).

2.2. 1D-barcodes

One-dimensional (also linear) Barcodes are made only from vertical stripes. Each type of barcode has its own specification. Here are the basics terms for barcodes:

- Symbology: mapping between text and barcodes (how should be text transported to bars and spaces
- Barcode Density: how much space is required for character (mostly interpreted as number of characters in centimeter)
- Valid characters: list of characters, which can be used in barcode
- Module width: The width of the smallest bar (or space), which can be used in barcode (marked as “X” parameter)
- Quiet zone: Area all over barcode, where should not be any character or mark to ensure barcode best readable possibility (the rule: quiet zone should be ten times dimension of module width)
- Obtain check digit: one or more digits in barcode, which perform mathematical check to valid whole barcode

One dimensional barcodes have a lot of types. Worldwide there are at least nine barcode standards in use. [7] From that reason it is almost impossible to name all of barcodes

nowadays useable. On Figure 2 You can see comparison between two barcode types, which are using worldwide. On this comparison are showed basics barcode characteristics.

Figure 2: *Comparison between EAN-13 and Code 128*

Parameter	EAN-13	Code 128
Symbology number	13	20
Number of digits	12 + 1 for checking	108
Valid characters	Only numerical digits	Alfa-numerical digits, some special symbols (&,@, e.c)
Quiet zone	11X from left, 7X from right	10X (minimal 0,25 inch
Module width	X=0,33 mm	X>=0,19 mm

Source: TEC-IT [9], BarCode generator [5]

2.3. 2D barcodes

Two-dimensional barcode can be characterized like graphical object that stored information horizontally (as one dimensional barcodes) and vertically, at the same time. If 1D code 128 have can obtain 108 digits, Two dimensional barcodes can store up 7 000 characters depending on its type.

Worldwide most useable 2D-barcode is so called QR code.[10] Abbreviated from "Quick Respond", from its development in 1994, when QR code obtain "only" 127 numeric digits, to newest generations of QR codes (7 089 digits, or 1817 Japanese kanji symbols) QR codes usage rapidly grows.

Figure 3: *Example of QR code*

Source: QR Codes [11]

QR code from Figure 3 is a small sized one. Size of QR code is not measurable in units of length, but in so called modules. Each module can be imagined like data carrying device, which mean more modules provides more place for data. QR codes have functionality

of self recovering, which mean, if some modules of barcode are damaged, other parts of barcode can restore data. QR codes with lowest error correction demands, 7 % of modules can be restored. In other words, if 7 % of QR code is damaged, readers can read all content. In opposite side, QR with highest data restoration demand can restore 30 % of content.

3. RFID

This modern technology is contactless method for identification of object. The usage of this technology is grooving very fast: RFID itself is considered as successor of barcodes.

3.1. Background

Radio frequency identification (RFID) as a wireless technology is rapidly becoming very popular because of its cost-effectiveness. Great merit on it has US Department of Defense (DoD) as world's largest supply chain operator and corporation Wal-Mart as world's largest retailer. [8] In 2003 both of them requested on top suppliers RFID tagging on pallets. Because of their size of operations, the RFID industry quickly began grown.

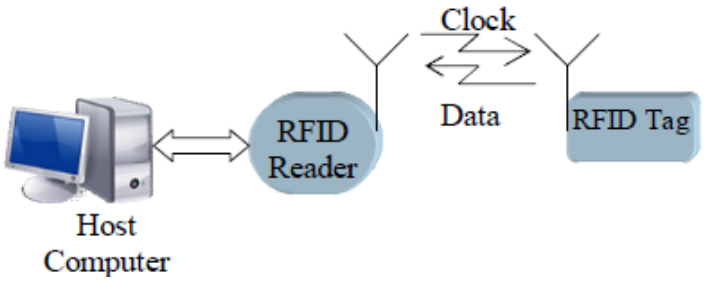
3.2. RFID components

Radio-frequency identification uses wireless technology for tagged object identification. Because of different logic of tagging, there have to be different components on RFID systems compared to barcodes. There are three basic components:[6]

- Tag – Data carrying device. This component has to be placed on object, which is planned to be identified (e.g. on pallet with material). Sometimes is called transponder.
- Reader –It depends upon design and technology used, this device is intended to read (or read & write, if it is needed for operation) data from tag. Sometimes is called interrogator.
- Controller – Device for decoding (or encoding) data from RFID tag and data gathering. Sometimes is called a host. Often takes the form of a PC with some control software.

Tags and readers communicate between each other using radio waves. In case of entrance of tagged object into reading zone, interrogator reads data from tag and sends it to controller. Communication between host device and reader uses standard network interface (data cable connection, Wi-Fi, etc.). Based on data decoded from tag, controller has many purposes. Tagged object for example can be inventoried in a database or redirected to demanded space. Whole principle of RFID technology is shown on figure 4.

Figure 4: *Overview of RFID systems*



Source: (Dobkin, 2013) [3]

RFID system could contain a large number of RFID tags and readers all over specific area. RFID technology can manage about 1000 tags per second with accuracy of 98%. [1, 14] Every transponder required energy supply. In way of energy supplying RFID tags can be divided on passive and active.

Passive transponders do not obtain power supply. There receive energy via magnetic (or electro-magnetic) field, which is emitting from readers. This field can be modeled from the interrogator, another way is intermediately store energy in the transponder (for a short time).in other words, reader emitted energy for transmission from reader to tag and back to reader. This mean, if the transponder is not located in reader's range, tags have no power supply and are unable to send any signals.

Active transponders have their own power supply (e.g. from battery or solar cell). The supply provides energy to the tag. For this reason magnetic field is no more necessary for power supply transponder, which mean, magnetic field can be much weaker than the field required for passive tags. If the reader is able to detect weak signal, communication area between reader and tag can be increased.

Both active and passive transponders need reader's magnetic (or electromagnetic) field for data transmission to the controller via reader. For that reason there are limitations of reading areas, the maximum achievable range is 15 m. [4]

3.3. RFID terms

RFID systems can be described with for RFID typical characteristics. Considers basics terms used for RFID technology as follows: [7]

- Operating frequency: frequency of magnetic (or electromagnetic) field, which is used for transmission between readers a tag. depending on frequency RFID can be divided to:
  - Low frequency (125-134 kHz)
  - High frequency (about 13,56 MHz)
  - Ultra-high frequency (860-960 MHz)
  - Microwave (2.5 GHz and above)

- Read Range: Area when signal from reader can reach transponder and can receive data from it. In lower frequencies, read ranges are about 1 meter, ultra high frequencies can reach read range about 10 meters.
- Kind of tags: active or passive
- Interference: RFID systems are vulnerable from other radio systems. Signal from other radio systems can falsify data received from tag, or even interrupt signal. Due low frequency of radios, more vulnerable are low frequency – RFID
- Data rate: represent data size, which can be transmissioned between RFID tags and readers per second. Similarly to read range, higher frequencies have higher data rate.

4. Comparison between RFID and Barcodes

RFID and Barcodes are nowadays worldwide most used AIDC systems. In this on mind comparison between them are only logical.

Figure 5: *comparison between Barcode and RFID*

Parameters	Barcode	RFID systems
Typical data quantity	<100 b	16-64 kb
Readability by people	Good	Impossible
Influence of dirt	Very high	No influence
Influence of optical covering	Very high	No influence
Degradation	Limited	No influence
Purchasing costs	Low	Medium
Operating costs	Low	None
Reading speed	About 4s	Less than 0,5 s
Maximum distance	0,5m	5 m

Source: Finkenzeller 2010 [4], modified by Author

RFID technologies seem to have better utilization: RFID technologies have almost no influence from space around data carrying device in contrast of barcodes, where some cleanliness can disable reading from barcode. [4] From other side, one dimensional barcodes usually have coded text right below barcode, so the functionality can be saved. In case of RFID-tag failure data saving is very difficult (and often not possible). Impurity of barcode, mechanical demolition as further degradations is another advantage of RFID, life time of RFID tags is much higher than barcodes, even if they have ability to partially restore themselves.

Big disadvantage of Barcodes is the fact, that once the barcode is printed, data on it can be changed. RFID can use rewritable tags, which can change data carried on it, in some conditions. RFID systems have in average ten times higher distance between data carrying device and reader, on top of that reader have ten times higher speed of reading data. Costs of purchasing and operating are favoring RFID, either.[13]

5. Nowadays usage of AIDC systems

As mentioned before, there are a lot of AIDC technologies, which are currently used worldwide. However some systems are applied dedicated branch more fervently and more often than others. Here is the basic field of usage of AIDC systems. [7]

Barcode is worldwide most used technology for Auto-ID. Barcodes, as the oldest of AIDC technologies, could be used almost everywhere. In daily life, barcodes can be found in groceries – Universal Product Codes UPC or European Article Number EAN, in warehousing – material labels, movements orders etc.

Barcodes are frequently using in shipping documents. In VDA [12] standard etiquette there are several information: Vendor identification, material, quantity, delivery number and some other data requested by customer, each in barcode – mostly in Code128. All of this information is often united in one 2D Barcode. With this standardization barcodes system reaches its full potential. Barcodes are using in other label standards (ODETTE, AIAG, etc) either.

Speaking about shipping, Barcodes are often seen in delivery document header. In cooperation with EDI systems (ASN is perfect example) these barcodes also contains information necessary to quick material income.

Usage of Smart Card is not growing recently. This technology required contact between reader data-carrier devices, which in days of no-contact technologies is not preferred. However, there are still some areas, where this technology has a sense: [7, 4] telecommunication (SIM card), Credit Cards (in contrast with non-contact card, Smart Cards provides more safety against hackers).

RFID technologies are often used on places, where barcodes are not enough, for example tracking of material transport to be sure, where material is in flow of time. Compared to barcodes, RFID technologies provide quicker measurement in time, more accurate data and faster evaluation of them.

Both, Smart Cards and RFID, are frequently using in cooperation with NFC (Near Field Communication) in cross-docking centers, especially in case of package deliveries. In cross-docking centers is time more important than everything else. In that case NFC technology provides perfect solution for very fast sorting packaging depending on its target destination. [2]

Conclusions

At the present time barcodes are used for tagging material for example in grocery, material flow or industry. RFID technology is growing rapidly, especially in USA, thanks to Department of Defense and Corporation Wal-Mart. RFID systems increase operational efficiently, higher efficiency lowers organizations cost and increases profit

This paper summarizes Auto Identification and Data Captures, compares RFID and Barcode, which are most useable from AIDC systems. Taking into account development of market behavior, when more demand of RFID technologies should decrease costs of FRID systems, greater grow of RFID implementation can be expected. . From this reason, more and

more RFID trials are being announced every month. RFID technologies have the potential to replace barcode systems in the future.

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Acknowledgements

This article is published within the solution of projects

Internal development competition at University of Pardubice IRS2016/017- The innovation of the courses Logistics II, Logistics I in the DMML field of study and Technology and management of the postal operation, Mechanization and Automatization of Postal Services in the MEKPS field of study within the modernization of the AIDC Laboratory

Student Grant Competition of University Pardubice, the project number: SGS_2016_008

Resume

The aim of this paper is to defined systems of automatic identification and data capture currently used in world and analysis fields of utilization these systems in logistic processes. Nowadays most used type of AIDC is Barcode technology because of its low initial costs and easy maintenance. Barcodes are mostly used in groceries and warehousing, so there where are no need of data changing. In other side, it's only matter of time, when will Barcodes be replaced with RFID technology, which popularity is increasing.

Key words

Automatic identification and data capture, radio frequency identification, barcode, QR code

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