



APPLICATION OF RFID TECHNOLOGY IN LOGISTICS AND OTHER FIELDS

MOGUĆNOST PRIMENE RFID TEHNOLOGIJE U LOGISTICI I DRUGIM OBLASTIMA

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Abstract: *RFID is a modern information and communication technology which enables contactless identification of objects with tags. Tags are devices consisting of a microchip and an antenna and they contain data about different objects on which they are placed. RFID provides many advantages and can be applied in different fields: traffic and transportation, production systems, agriculture, biometrics, governmental administration, etc. This paper describes RFID technology and applications in logistics and other fields.*

Key words: *RFID, tags, identification, logistics, supply chain*

Apstrakt: *RFID je savremena informaciono-komunikaciona tehnologija koja omogućava bezkontaktnu identifikaciju objekata obeleženih tagovima. Tagovi su uređaji koji se sastoje od mikročipa i antene i sadrže podatke o objektima na koje su postavljeni. RFID obezbeđuje velike prednosti i može se primeniti u različitim oblastima: saobraćaju i transportu, proizvodnim sistemima, poljoprivredi, biometriji, državnoj administraciji i dr. U ovom radu je opisana RFID tehnologija i primena u logistici i drugim oblastima.*

Ključne reči: *RFID, tagovi, identifikacija, logistics, lanci snabdevanja*

1 INTRODUCTION

Radio Frequency Identification (RFID) is a technology allowing contactless reading and wireless transmission of data contained on tags. The RFID was first applied in 1940 by the US Army to label the allied aircrafts in World War II to distinguish them from foe ones. Since 1980 it has been used for improving the production systems control (Kent, 2006). The past two decades have seen a significant commercial use of RFID in a variety of areas ranging from marking vehicles, animals and plants to tracking goods, documents and people.

1 UVOD

Radio frekventna identifikacija (RFID) je tehnologija koja omogućava bezkontaktno očitavanje i bežični prenos podataka sa tagova. Prva primena RFID-a je bila 1940. godine u američkoj vojsci za obeležavanje savezničkih aviona u II svetskom ratu kako bi se razlikovali od neprijateljskih. Od 1980. godine primenjuje se u sistemima za poboljšanje kontrole proizvodnje (Kent, 2006). Značajnu komercijalnu primenu RFID ima poslednjih dvadeset godina u različitim oblastima, od obeležavanja vozila, životinjskih i biljnih jedinki do praćenja robe, dokumenata i ljudi.

This paper presents the RFID technology and its applications in logistics, supply chains and other fields. It consists of three parts. The first describes tags as the basic elements of RFID technology. The second presents the RFID technology itself and its functioning. The third part treats the applications of RFID technology in some important fields.

U ovom radu je opisana RFID tehnologija i mogućnosti njene primene u logistici, lancima snabdevanja i drugim oblastima. Rad obuhvata tri celine. Prvi deo opisuje tagove, kao osnovne elemente RFID tehnologije. Drugi deo predstavlja opis i način funkcionisanja RFID tehnologije. Treći deo prikazuje mogućnosti primene RFID-a u nekim najznačajnijim oblastima.

2 RFID TAG

Simply speaking, RFID tags are "smart tags" bearing a large amount of information. Terms transponder, tag or RFID tag are used as having equal meanings. Each tag consists of two basic components: a microchip and an antenna. The microchip stores data whereas the antenna permits communication with a reader. A RFID tag is shown in Figure 1.

2 RFID TAG

RFID tagovi se najjednostavnije mogu opisati kao "pametne pločice" koje nose veliku količinu informacija. U upotrebi su termini transponder, tag ili RFID tag koji imaju isto značenje. Svaki tag se sastoji od dve osnovne komponente: mikročipa i antene. Mikročip čuva podatke a antena omogućava komunikaciju sa čitačem. Na slici 1 je prikazan jedan RFID tag.

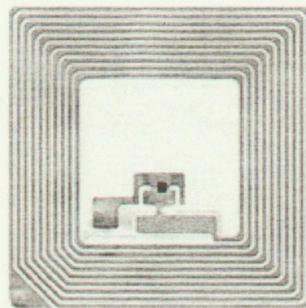


Figure 1 RFID tag
slika 1 RFID tag

According to their characteristics, tags may be classified into various groups: according to the type of power supply, according to data storage possibilities, operating frequency and the distance of reading site, physical shape and price (Finkenzeller, 2003). There are three types of tags:

- Active,
- Passive, and
- Semi-Passive.

Active tags have their own battery that supplies power to the microchip and allows signals to be emitted to a reader. Signals may be emitted from a larger distance (up to 100 m) or when initiated by a reader. Active tags may store a larger amount of information than passive ones and they permit data entry, reading and retrieval. The lifecycle of active tags is relatively short (5 to 10 years) and their price ranges from 10\$ to 20\$ per unit (LXE, 2006).

Tagovi se prema karakteristikama mogu podeliti u različite grupe: prema načinu napajanja, mogućnosti čuvanja podataka, radnoj frekvenciji i udaljenosti čitanja, fizičkom obliku i ceni (Finkenzeller, 2003). Postoje tri tipa tagova:

- Aktivni,
- Pasivni, i
- Polupasivni.

Aktivni tagovi imaju sopstvenu bateriju koja napaja mikročip i omogućava emitovanje signala čitaču. Signal se može emitovati na većoj udaljenosti (do 100 m) neprekidno ili kada ga čitač pobudi. Aktivni tagovi mogu nositi veću količinu informacija od pasivnih tagova i omogućavaju upis, čitanje i pretraživanje podataka. Životni vek aktivnih tagova je relativno kratak (5 do 10 godina) a cena se kreće od 10\$ do 20\$ po komadu (LXE, 2006).

Passive tags are supplied by electrical signals sent from a reader. Data from a passive tag may be read when a tag is besides a reader and the range is from 0.5 m to maximum 5 m. Their advantage is a low price and a long lifecycle, making them used widely (www.alientechnology.com).

Semi-passive tags have their own battery that supplies power without communication with a reader. These tags show the best performances: capacity, range and lifecycle. Semi-passive tags are used most often for marking expensive goods in supply chains (www.rfidtoday.co.uk).

The RFID technology supports various possibilities for reading from and writing to a tag (www.etag.co.yu):

- **Read Only (RO)** – a tag can be read only and it obtains its unique serial number in the production process. Once stored, information cannot be changed.
- **Read Write (WR)** – a user may write information several times. Tags provided with this capability mainly have a serial number that cannot be deleted, whereas other data may be entered subsequently.
- **Multi- Page (MP)** – these tags consist of RW tags whose memory is divided into memory pages that are programmable and readable independently of one another.

The RFID technology is based on a radio frequency signal between a reader and tag. RFID may be grouped into four frequency intervals: low, high, ultrahigh and microwave frequencies (www.epcglobalinc.org). The frequency interval and tag type affect RFID system performances: signal range and the speed of data reading and transmission between a reader and tag. The choice of a tag and operating frequency depends on the actual real conditions prevailing in a business system for which a RFID system is being designed.

3 RFID TECHNOLOGY DESCRIPTION

Radio Frequency Identification (RFID) is an automatic identification technology relying on a system for wireless reading and transmission of data using radio waves. RFID systems comprise three basic components:

Pasivni tagovi se napajaju električnim signalom koji dobijaju od čitača. Podaci sa pasivnog taga se mogu pročitati kada se tag nalazi pored čitača a domet može biti od 0.5 m do najviše 5m. Njihova prednost je niska cena i dugotrajnost što im omogućava masovnu primenu (www.alientechnology.com).

Polupasivni tagovi imaju sopstvenu bateriju koja ih napaja energijom bez komunikacije sa čitačem. Ovi tagovi imaju najbolje performanse: kapacitet, domet i životni vek. Polupasivni tagovi se najčešće koriste za obeležavanje skupe robe u lancima snabdevanja (www.rfidtoday.co.uk).

RFID tehnologija podržava različite mogućnosti čitanja i upisivanja na tag (www.etag.co.yu):

- **Read Only (RO)** – moguće je samo čitanje taga koji u procesu proizvodnje dobija svoj jedinstven serijski broj. Jednom smeštena informacija više se ne može menjati.
- **Read Write (RW)** – korisnik može više puta upisati informaciju. Tagovi sa ovom mogućnošću uglavnom imaju serijski broj koji se ne može izbrisati, a drugi podaci se mogu dodatno upisivati.
- **Multy Page (MP)** – tagovi se sastoje od RW tagova kod kojih je memorija podeljena na memorijske stranice koje se mogu nezavisno programirati i čitati.

RFID tehnologija se zasniva na radio frekventnom signalu između čitača i taga. RFID se može grupisati u četiri frekvenčska intervala: niske, visoke, ultravisoke i mikrotalasne frekvencije (www.epcglobalinc.org). Frekvenčski interval i vrsta tagova utiču na performanse RFID sistema: domet signala i brzina čitanja i prenosa podataka između čitača i taga. Izbor tagova i radne frekvencije zavise od konkretnih realnih uslova poslovnog sistema za koje se projektuje RFID sistem.

3 OPIS RFID TEHNOLOGIJE

Radio frekventna identifikacija (RFID) je tehnologija automatske identifikacije koja podrazumeva sistem za bežično očitavanje i prenos podataka putem radio talasa. RFID sistemi se sastoje od tri osnovne komponente:

- Tags,
- Readers with an antenna, and
- A central computer.

- Tagovi,
- Čitači sa antenom, i
- Centralni računar.

Tags are placed on objects that should be identified. RFID systems are designed with passive, active and/or semi-passive tags. Regardless of type, tags may be of various forms: labels, appendages, cards, etc. Tags may be placed on traffic, transportation and materials handling vehicles, logistic units, single products in retail, plants or animals, special goods (money, gold, medicines), may be given to people as identification cards or documents, etc.

RFID readers are devices provided with antennas and are primarily intended to scan tags. They verify a tag and read and transform radio waves emitted by a tag into a form suitable for further processing. Readers can read a large number of tags in a very short time. As RFID technology is developing rapidly, readers available today can read several hundred and even a thousand of tags simultaneously. Tag readers may be of a portal form, wall mountable, hand held, etc. Some RFID readers are presented in Figure 2.

A **central computer** and software are the most important part of an RFID system. Software collects data and interconnects tags, readers and antennas into an integral system. An RFID system architecture is shown in Figure 3.

Tagovi se postavljaju na objekte koje je potrebno identifikovati. RFID sistemi se projektuju sa pasivnim, aktivnim i/ili polupasivnim tagovima. Bez obzira na vrstu korišćenog taga, oni mogu biti različitih oblika: nalepnice, privesci, registracioni uređaji, kartice, i dr. Tagovi se mogu postavljati na saobraćajna, transportna i pretovarna sredstva, logističke jedinice, pojedinačne artikle u maloprodali, biljke ili životinje, njima se mogu obeležavati specijalni tereti (novac, zlato, lekovi), mogu se davati ljudima kao identifikacione kartice ili dokumenta, i dr.

RFID čitači su uređaji sa antenom, čija je osnovna uloga da skeniraju tagove. Oni verifikuju tag i očitavaju i pretvaraju radio talase emitovane od taga u oblik pogodan za dalju obradu. Čitači mogu u veoma kratkom vremenu da očitaju veliki broj tagova. RFID tehnologija se neprestano razvija tako da danas postoje čitači koji mogu očitavati više stotina, pa i hiljadu tagova istovremeno. Čitači tagova mogu biti različiti: portalni, zidni, ručni i dr. Na slici 2 su prikazani neki RFID čitači.

Centralni računar i softver su najvažniji deo RFID sistema. Softver prikuplja podatke i povezuje tagove, čitače i antene u jedinstven sistem. Na slici 3 je prikazana arhitektura RFID sistema.

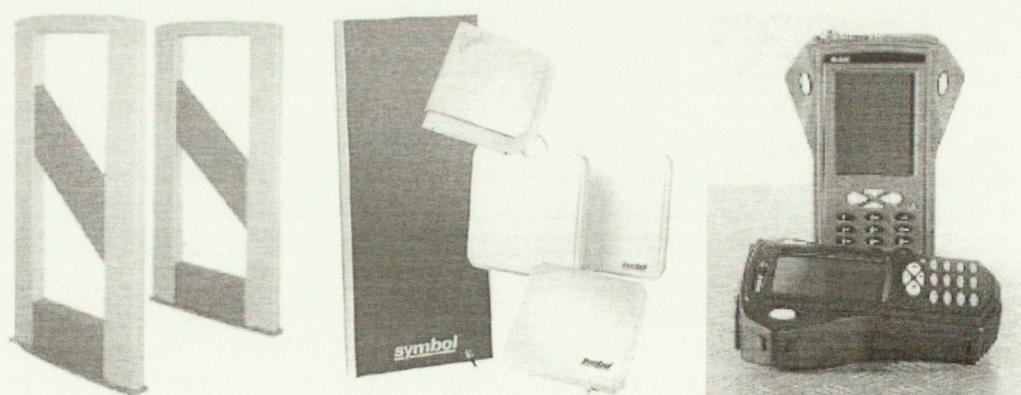


Figure 2 RFID Readers (portal, wall-mounted and hand-held)
slika 2 RFID čitači (portalni, zidni i ručni)

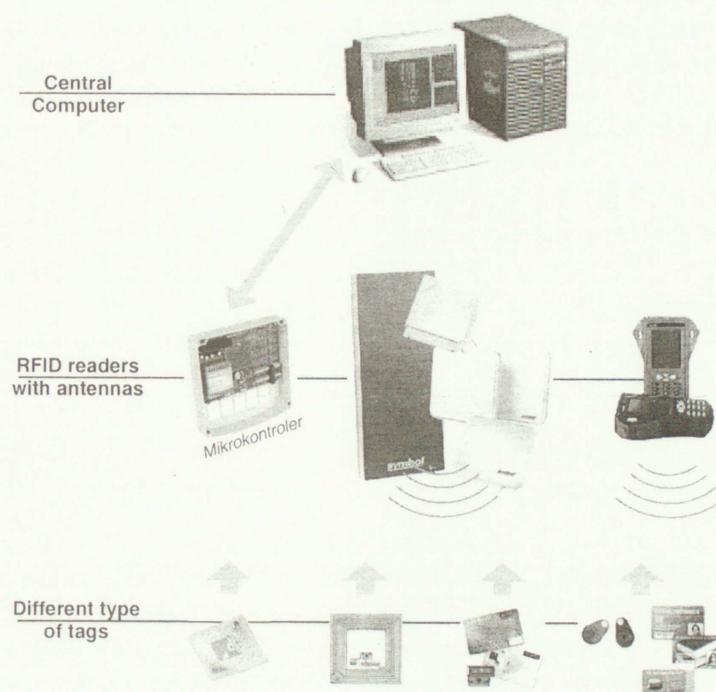


Figure 3 RFID System Architecture
slika 3 Arhitektura RFID sistema

Data collected by using the RFID technology are very useful for the realization of various business activities. The RFID software is needed to connect the information read from a tag with the remaining business software systems and thus benefit as much as possible from all the advantages offered by RFID. The following business software is most frequently connected with RFID (Fernie, Sparks, 2004):

- Warehouse management systems - WMS
- Traffic Management System - TMS
- Environmental Management System - EMS
- Order Management System - OMS and
- Enterprise Resource Planning - ERP.

The use of RFID technology provides numerous advantages and positive effects in all application fields. These advantages include:

- Data from tags are readable without direct visibility – a tag does not have to be within a reader's visibility field. This feature provides automatic scanning of a larger number of tags at high speeds. The knowledge of ***what*** is available and ***where*** it is located contributes directly to improved efficiency and effectiveness of business processes.

Podaci prikupljeni RFID tehnologijom su od velike koristi pri realizaciji različitih poslovnih aktivnosti. RFID softver je neophodan da bi se informacije pročitane sa taga povezale sa ostalim poslovnim softverskim sistemima i time na najbolji način iskoristile sve prednosti koje pruža RFID. U poslovne softvere sa kojima se RFID najčešće povezuje spadaju (Fernie, Sparks, 2004):

- Skladišni menadžment sistem - WMS,
- Transportni menadžment sistem - TMS,
- Menadžment događaja - EMS,
- Menadžment sistema naručivanja - OMS,
- Sistem za planiranje resursa - ERP.

Primena RFID tehnologije pruža brojne prednosti i pozitivne efekte u svim oblastima primene. Neke od prednosti su:

- Mogućnost očitavanja podataka sa tagova bez direktnе vidljivosti – tag ne mora biti u direktnom vidnom polju čitača. Ova osobina obezbeđuje automatsko skeniranje većeg broja tagova velikom brzinom. Saznanje ***šta*** je na raspolaganju i ***gde*** se nalazi direktno utiče na povećanje efikasnosti i efektivnosti poslovnih procesa.

- Tags may store a large amount of data that can be retrieved, deleted and entered.
- Applicable in different environmental conditions as regards climate, business and organization. Tags are contactless, iresistant, endurable, unnoticeable and long lasting.
- Tags provide real-time product tracking along the entire supply chain, contributing thereby to lower cost, improved service quality and higher business process realization reliability.
- The use of tags in retail chains reduces considerably labour engagement needs as well as human errors in data entry. According to some data (Alling et al., 2004), labour costs in the USA account for 30% of the total supply chain expenditure.
- Tagovi mogu da sadrže veliku količinu podataka, koji se po potrebi mogu pretraživati, brisati i upisivati.
- Primena RFID tehnologije u različitim uslovima okruženja: klimatskim, poslovnim i organizacionim. Tagovi su bezkontaktni, otporni, izdržljivi, neprimetni i dugotrajni.
- Tagovi obezbeđuju praćenje proizvoda u realnom vremenu duž celog lanca snabdevanja. Ovime se postiže smanjenje troškova, povećanje kvaliteta usluge i povećanje pouzdanosti realizacije poslovnih procesa.
- Primena tagova u maloprodajnim lancima u značajnoj meri smanjuje angažovanje radne snage i ljudske greške pri unosu podataka. Prema nekim podacima (Alling i dr., 2004) u SAD troškovi radne snage iznose 30% ukupnih troškova lanaca snabdevanja.

Apart from numerous advantages, the RFID technology also has some disadvantages. Some of them are:

- The cost of implementing RFID systems is still high. Tags themselves are not expensive, but they account for a smaller part of investment required to implement these systems.
- The reliability and precision of tag reading have not been brought to a needed level. Multiple reading or failure to read is the main problem in reading the contents of tags. In Wal-Mart pilot project (Sanford, 2003), the precision of readings appeared to be no more than 75%.
- The vicinity of metals or an electromagnetic field may have negative effects on RFID system functioning.
- Tags can be read on sites where their users do not wish to be identified and tracked.

I pored brojnih prednosti RFID tehnologija ima i određene nedostatke. Neki od njih su:

- Cena uvođenja RFID sistema je i dalje visoka. Tagovi nisu skupi ali oni predstavljaju samo manji deo investicija u ovaj sistem.
- Pouzdanost i preciznost očitavanja tagova još uvek nisu na potrebnom nivou. Glavni problem pri očitavanju je višestruko očitavanje ili neočitavanje taga. Preciznost očitavanja u Wal Martovom pilot projektu iznosila je samo 75% (Sanford, 2003).
- Blizina metala ili elektromagnetskog polja može negativno da utiče na funkcionisanje RFID sistema.
- Mogućnost očitavanja tagova i na lokacijama gde njihovi korisnici ne žele da budu identifikovani i praćeni.

4 RFID TECHNOLOGY APPLICATIONS

The advantages gained through the use of RFID technology indicate its wide applicability in a variety of fields – industry, service sector, governmental administration, biometrics, etc. Tags of different shapes and sizes are available today that can be employed to label: goods, transport, traffic and materials handling vehicles,

4 PRIMENA RFID TEHNOLOGIJE

Prednosti primene RFID tehnologije ukazuju na velike mogućnosti primene u različitim oblastima – privrednim delatnostima, uslugama, državnoj administraciji, biometriji i dr. Danas postoje različiti oblici i dimenzije tagova kojima se mogu obeležavati: roba, transportna, prevozna i pretovarna sredstva, ljudi, dokumenta, biljne i

humans, documents, plants and animals. The research performed and the systems designed illustrate the use of tags in nearly all life and work segments – from traffic and transportation, product flow labeling, pharmacology and medicine, to electronic documents and marking of living beings. In this paper we describe the RFID applications in: logistics, supply chains, access control, pay toll systems, plant and animal identification and biometrics.

4.1 LOGISTICS

The RFID technology is applicable in all logistic subsystems: transport, materials handling, production, warehousing, ordering, distribution. The possibility to acquire, integrate and process data from tags permits high-quality and more efficient organization of logistic processes and activities, reduced inventory levels and enhanced human and equipment productivity.

The incorporation of RFID into an integrated company information system (IS) brings advantages to all work segments: automatic generation of inventory level reports, purchase order processing and realization, inventory replenishment, problem identification in commission system, reports on materials handling and transportation vehicles operation, etc.

životinjske vrste. Realizovana istraživanja i projektovani sistemi pokazuju primenu tagova u skoro svim segmentima života i rada – od saobraćaja i transporta, preko obeležavanja robnih tokova, farmakologije i medicine, do elektronskih dokumenata i obeležavanja živih bića. U ovom radu je prikazana primena RFID u: logistici, lancima snabdevanja, kontroli pristupa, naplatnim sistemima, identifikaciji biljnih i životinjskih jedinki i biometriji.

4.1 LOGISTIKA

RFID tehnologija ima mogućnost primene u svim podsistemima logistike: transportu, pretovaru, proizvodnji, skladištenju, naručivanju, distribuciji. Sposobnost prikupljanja, čuvanja, integrisanja i obrade podataka sa tagova omogućava kvalitetnije i efikasnije organizovanje logističkih procesa i aktivnosti, smanjenje nivoa zaliha i poboljšanje produktivnosti radnika i opreme.

Integracija RFID u jedinstveni informacioni sistem (IS) kompanije obezbeđuje prednosti u svim segmentima rada: automatsko dobijanje izveštaja o stanju zaliha, obrada i realizacija porudžbina, popunjavanje zaliha, identifikovanje problemskih tačaka u sistemu komisioniranja, izveštaji o radu pretovarne mehanizacije i transportnih sredstava, i dr.

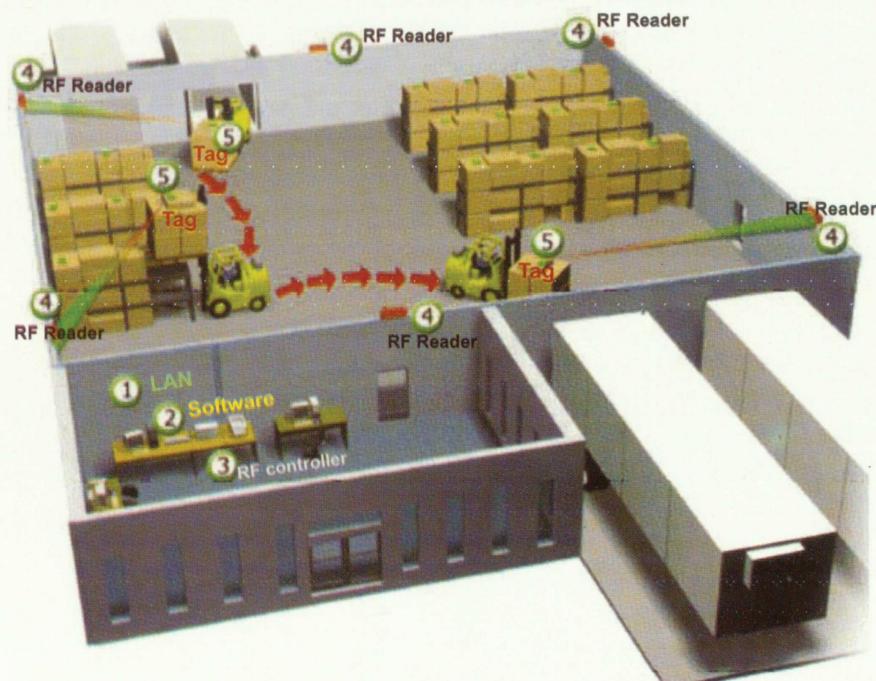
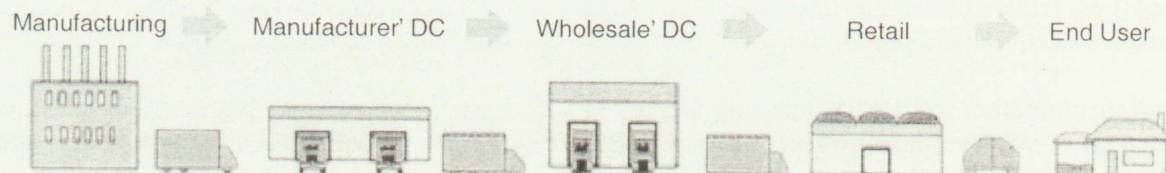


Figure 4. RFID Application in Logistics
slika 4 Primena RFID u logistici

Figure 4 presents RFID technology application in a warehouse (www.wherenet.com). The RFID tags (5) placed on articles emit signals at particular time intervals. These signals are received by readers (4) installed in the warehouse. Received data are sent through a cable or wireless local network (1) to a RF controller (3) and locating software (2) which determine the location of each object provided with a tag.

4.2 SUPPLY CHAINS

The RFID technology is applied by all participants of a supply chain from a producer to an end user (Figure 5). Marking goods (containers, palettes, boxes, products) by tags permits visibility, tracking and obtaining timely and accurate information along the entire chain.



*Figure 5 Supply chain
slika 5 Lanac snabdevanja*

The lack of visibility and integration in a supply chain may result in: production line interruptions, high inventory levels in warehouses and increased costs. Communication, cooperation and exchange of timely information among all participants are a prerequisite of success on a global market. The use of RFID technology provides: tracking the realization of commodity flows, inventory level minimization in all participants, reduction of total costs, smaller numbers of employees, etc.

4.3 ACCESS CONTROL

Access control means the automatic identification of tags on controlled access sites in particular zones. Tags in the form of cards and appendages (Figure 6) are used most widely.



*Figure 6 Access Control Tags
slika 6 Tagovi za kontrolu pristupa*

Na slici 4 je prikazana primena RFID tehnologije u jednom skladištu (www.wherenet.com). RFID tagovi (5) su postavljeni na artikle i emituju signal u određenom vremenskom intervalu. Taj signal primaju čitači (4), koji su postavljeni u skladištu. Primljeni podaci šalju se preko kablovske ili bežične lokalne mreže (1) do RF kontrolera (3) i softvera za lociranje (2), koji određuju lokaciju svakog objekta sa tagom.

4.2 LANCI SNABDEVANJA

RFID tehnologija se primjenjuje kod svih učesnika u lancima snabdevanja – od proizvođača do krajnjeg korisnika (slika 5). Obeležavanje robe (konteneri, palete, kutije, proizvodi) tagom omogućava vidljivost, praćenje i dobijanje pravovremenih i tačnih informacija duž celog lanca.

U lancu snabdevanja koji nema karakteristike vidljivosti i povezanosti posljedice mogu biti: zastoji na proizvodnim linijama, velike zalihe u skladištima i porast troškova. Komunikacija, saradnja i razmena kvalitetnih informacija između svih učesnika su preduslov uspeha na globalnom tržištu. Primena RFID tehnologije omogućava: praćenje realizacije robnih tokova, minimizaciju nivoa zaliha kod svih učesnika, smanjenje ukupnih troškova, smanjenje potrebnog broja zaposlenih, i dr.

4.3 KONTROLA PRISTUPA

Kontrola pristupa podrazumeva automatsku identifikaciju tagova na mestima kontrolisanog pristupa određenim zonama. Tagovi koji se koriste su najčešće u obliku kartica i privezaka (slika 6).

The RFID card is of a credit-card size and a company logo, username, advertisement, photograph, etc. can be printed on it. The RFID reader is placed on the entry barrier and/or registers entry to a system. Access control is employed in business office areas, hotels, factories, sports centers, at public manifestations, etc.

Figure 7 presents vehicle and employee access control in a company. Cards may be programmed in various ways: a limited validity time, a particular number of entrances, different access levels for particular zones, limited credit amounts, etc.



*Figure 7 Vehicle and Employee Access Control in a Company
slika 7 Kontrola pristupa vozila i zaposlenih u kompaniji*

The use of RFID cards in companies permits: automatic recording of employees' work hours, of the number of entries to a parking lot, of restaurant usage, of company's vehicle departure times, obtaining reports on the movements of external users, etc.

RFID kartica je veličine kreditne kartice i na nju je moguće štampati logo kompanije, ime korisnika, reklamu, fotografiju i sl. RFID čitač se postavlja na ulaznu rampu i/ili vrata i evidentira ulazak u sistem. Kontrola pristupa se primjenjuje u poslovnim prostorima, hotelima, fabrikama, skladištima, sportskim centrima, javnim manifestacijama i dr.

Na slici 7 je prikazana kontrola pristupa vozila i zaposlenih u kompaniji. Kartice mogu biti programirane na različite načine: ograničeno vremensko trajanje, određeni broj ulaza u sistem, različiti nivoi pristupa određenim zonama, ograničeni iznos kredita na karticama, i dr.



Primena RFID kartica u kompanijama omogućava: automatsko evidentiranje radnog vremena zaposlenih, broj ulazaka na parking, korišćenje restorana, vreme odlazaka vozila na teren, dobijanje izveštaja o kretanju spoljašnjih korisnika, različite statističke analize o korišćenju poslovnih sadržaja, i dr.

4.4. Pay Toll Systems

A large number of motorway toll or parking fee collection systems have been developed all over the world (USA, Italy, Slovenia, Croatia, Serbia, etc.). Prepaid and postpaid tags for electronic payments are available and their users either increase their credit amounts or pay their monthly bills.

In pay toll systems a tag is a device that contains data on a vehicle (owner, registration, category, credit amount, entry to a motorway / parking lot, ...) and is placed on a vehicle windscreen. When a vehicle enters a motorway/parking, data on entry location and time are written on the tag; when it leaves, toll payment is made. Electronic pay toll systems offer numerous advantages: toll

4.4. Različiti naplatni sistemi

U svetu su razvijeni mnogobrojni sistemi za naplatu putarine ili parkiranja preko tagova (SAD, Italija, Slovenija, Hrvatska, Srbija, i dr.). Tagovi za elektronsko plaćanje putarine/parkinga mogu biti pre-paid i post-paid i u zavisnosti od toga korisnik radi dopunu taga ili plaća mesečni iznos zaduženja.

Kod naplatnih sistema tag je uređaj koji sadrži podatke o vozilu (vlasnik, registracija vozila, kategorija, vrednost kredita, podaci o ulasku na autoput/parking, ...) i postavlja se na prednje staklo vozila. Pri ulasku na autoput/parking na tag se upisuju podaci o lokaciji i vremenu ulaska, a kada vozilo izlazi radi se naplata putarine/parkiranja. Elektronski naplatni sistemi omogućavaju niz prednosti: naplata se može

collection without stopping a traffic flow, a smaller number of toll collectors, automated processing of toll collection data, improved quality of service provided to users, etc. The tag employed for toll payment on motorways in Serbia is shown in Figure 8 (www.institutepupin.com).

raditi bez zaustavljanja saobraćajnog toka, smanjenje radne snage u naplatnim sistemima, automatizacija obrade podataka o naplati, povećanje nivoa kvaliteta koji se pruža korisnicima, i dr. Na slici 8 je prikazan tag za plaćanje putarine koji se koristi na autoputevima Srbije (www.institutepupin.com).



*Figure 8 Tag for Toll Payment in Serbia
slika 8 Tag za plaćanje putarine u Srbiji*

There exist examples of RFID applications for payments at petrol stations, shops and restaurants. The Exxon Mobil's Speedpass system (www.rfidjournal.com) has found a widespread use. This system employs RFID readers on cash registers for automatic payments of goods bought as well as for adding credit amounts on tags.

Postoje primeri primene RFID i u nekim korisničkim sistemima za plaćanje na benzinskim pumpama, u prodavnicama i restoranima. Veliku primenu postigao je Exxon Mobil's Speedpass system (www.rfidjournal.com). Ovaj sistem koristi RF čitače na kasama za automatsku naplatu kupljene robe i dopunu tagova.

4.5 IDENTIFICATION OF PLANTS AND ANIMALS

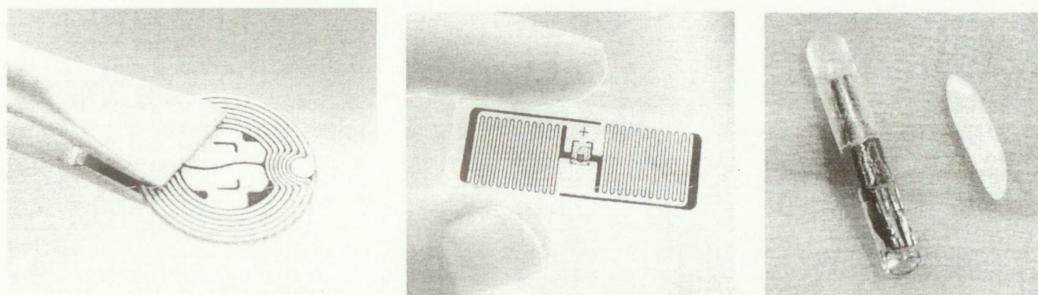
Marking of plant and animal units by RFID tags is widely used in the world. Tags contain various data on their carriers (identification number, owner, species, location, disease history, veterinary's visits, etc.) and are intended for control and protection against unauthorized activities. RFID tags are used for marking plant units from the growing period to final processing and end users. Data tracking through the whole chain of activities provides quality control and consumer protection. In the world of animals tags have found multiple applications: record keeping and protection of certain species from extermination, record keeping for domestic animals and their health control, pet databases, etc. In recent years diseases transmittable from animals to humans (mad cows, avian influenza) have been in expansion. The use of tags from the stage of animal raising through food processing industry to distribution contributes to the timely prevention of disease development.

4.5 IDENTIFIKACIJA BILJNIH I ŽIVOTINJSKIH JEDINKI

U svetu je u velikoj primeni obeležavanje biljnih i životinjskih jedinki RFID tagovima. Tagovi sadrže različite podatke o nosiocu (identifikacioni broj, vlasnik, vrsta, lokacija, istorijat bolesti, posete veterinara, ...) a osnovni cilj je zaštita i kontrola od neovlašćenih aktivnosti. RFID tagovi se koriste za obeležavanje biljnih jedinki od perioda uzgajanja do finalne prerade i krajnjih korisnika. Praćenje podataka kroz lanac aktivnosti omogućava kontrolu kvaliteta i zaštitu potrošača. U životinjskom svetu tagovi imaju višestruku namenu: evidentiranje i zaštita određenih vrsta od istrebljenja, evidentiranje domaćih životinja i kontrola njihovog zdravlja, baze podataka o kućnim ljubimcima i dr. Poslednjih godina je u ekspanziji pojava različitih bolesti koje se sa životinja mogu preneti na ljudе (lude krave, ptičji grip). Primena tagova od uzgoja životinja, preko prehrambene industrije, do distribucije namirnica, može pravovremeno sprečiti razvoj bolesti.

Figure 9 illustrates some examples of RFID tags implantable to animals. They are small in size (up to 2 x 2 x 0.5 mm), may be placed subcutaneously and carry large amounts of information.

Na slici 9 su prikazani neki primeri RFID tagova koji se kao implanti mogu "ugrađivati" životinjama. Ovi tagovi su malih dimenzija (do 2 x 2 x 0,5 mm), mogu se stavljati pod kožu i nose veliku količinu informacija.



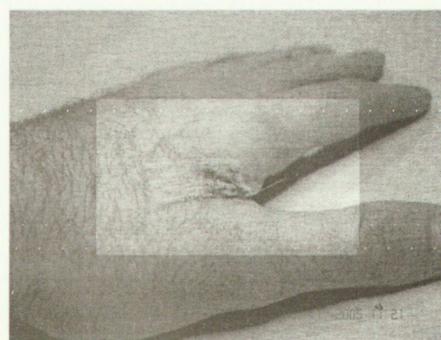
*Figure 9 RFID Tag Implants
slika 9 RFID tagoviimplanti*

4.6 BIOMETRICS

The rapid development of RFID technology has initiated studies into its possible applications to humans. As a result, small-sized tags – microchips – have been developed which are subcutaneously implantable and which contain medical data about persons carrying them. An emergency medical center is the most illustrative example of the use of this chip: an injured person is brought to a hospital; if there is a tag implanted, it is very easy to learn the required data on disease history, medicines taken and forbidden, previous medical interventions, etc. (www.idtechex.com). A RFID tag implant is shown in Figure 10.

4.6 BIOMETRIJA

Brz razvoj RFID tehnologije doveo je i do istraživanja mogućnosti njihove primene kod ljudi. Pojavili su se tagovi malih dimenzija – mikročipovi, koji se kao implanti mogu ugrađivati pod kožu i sadrže medicinske podatke o korisniku. Jedan od najočiglednijih primera primene ovog čipa je urgentni centar: povređena osoba se dovozi u bolnicu i ako ima ugrađen čip, veoma lako se mogu saznati podaci o istoriji bolesti, korišćenim i zabranjenim lekovima, prethodnim medicinskim intervencijama i slično (www.idtechex.com). Na slici 10 je prikazan RFID tag implant.



*Figure 10 RFID Tag Implant
slika 10 RFID Tag implant*

Ideas and solutions have recently appeared in the world to realize RFID systems in which a tag would replace personal documents: ID cards, passports, credit cards, etc. In addition to usual data, these electronic documents also contain personal biodata.

Poslednjih godina u svetu postoje ideje i rešenja za realizaciju RFID sistema u kojima tag zamenjuje lična dokumenta: ličnu kartu, pasoš, kreditne kartice i dr. Ovakva elektronska dokumenta osim ubičajenih podataka, sadrže i lične biopodatke.

Biometrics is a science and technology for a unique identification of humans by measuring their physiological and behavioral traits. RFID used in biometrics relies on electronic records of biodata: fingerprints, handprints, eye iris, etc. From a technical aspect, the application of RFID in biometrics may provide numerous advantages. However, a human is not a technical system. From a humane aspect, RFID and the capabilities it offers open up new possibilities for manipulation, abuse and identity theft and, above all, they permit humans to be tracked and controlled.

Countries that have planned to introduce biometric ID cards have faced public opposition and resistance: in Great Britain the attempt to introduce biometric personal documents initiated a several-month long parliamentary debate and dramatic reaction by the academic community; the British Government's Human Rights Committee found the biometric personal documents project to be in collision with the European Human Rights Convention; in Canada such a proposal was postponed as being expensive, unjustified and potentially dangerous; courts in Japan and Taiwan pronounced a verdict stating that the biometric ID cards project violated human rights and Constitutional provisions; in the USA there was no attempt to introduce such a system because it would arouse public opposition; ... examples are numerous.

5 CONCLUSION

The past two decades have witnessed a great expansion of RFID technology. Systems have been developed that are applied in nearly all work segments. Technological advances have brought various forms of tags (labels, devices, cards, appendages, implants) that may be used to mark vehicles, transportation devices, single products, documents, plants, animals and, even, humans (prisoners in America).

The capabilities provided by this technology offer numerous advantages in all technical and organizational systems. The drive to develop RFID further and use it more widely comes mostly from large multinational production and distribution companies, because they have already experienced the benefits gained by RFID. On the other hand, the use of tags in biometrics

Biometrija je nauka i tehnologija jedinstvene identifikacije ljudi merenjem fizičkih i psihičkih osobina. Primena RFID u biometriji podrazumeva elektronski zapis biopodataka: otisci prstiju, otisci dlanova, snimak dužice oka i dr. Sa tehničkog aspekta, primena RFID u biometriji može da obezbedi velike prednosti. Ali čovek nije tehnički sistem. Sa humanog aspekta, RFID i mogućnosti koje ova tehnologija pruža otvaraju nove prostore za manipulaciju, zloupotrebu i krađu identiteta, a pre svega omogućavaju nadzor i praćenje ljudi.

Zemlje, koje su planirale da uvedu biometrijske lične karte, suočene su sa otporom javnosti: u Velikoj Britaniji je pokušaj uvođenja biometrijskih isprava izazvao višemesecne polemike u parlamentu i burne reakcije akademske javnosti; Zajednički komitet za ljudska prava britanske vlade smatra da je projekat biometrijskih isprava u suprotnosti sa evropskom Konvencijom o ljudskim pravima; u Kanadi je ovaj predlog odbačen na neodređeno vreme kao skup, neopravdan i potencijalno opasan; sudovi u Japanu i Tajvanu su doneli presude da projekat biometrijskih ličnih karata krši prava građana i odredbe Ustava; u Americi nije ni bilo pokušaja uvođenja ovakvog sistema jer bi to dovelo do velikih otpora u javnosti; ... primera ima mnogo.

5 ZAKLJUČAK

RFID tehnologija je u poslednje dve decenije doživela veliku ekspanziju. Razvijeni su sistemi koji se primenjuju u skoro svim oblastima rada. Zahvaljujući napretku tehnologije, postoje različite forme i oblici tagova (nalepnice, etikete, uređaji, kartice, privesci, implanti) kojima se mogu obeležavati vozila, transportne jedinice, pojedinačni proizvodi, dokumenta, biljke, životinje, čak i ljudi (zatvorenici u američkim zatvorima).

Mogućnosti ove tehnologije obezbeđuju velike prednosti u svim tehničkim i organizacionim sistemima. Najveći pokretači daljeg razvoja i primene su velike svetske proizvodne i distributivne kompanije, koje su već doživele pozitivne efekte RFID-a. Sa druge strane, primena tagova u biometriji i obeležavanju ljudi otvara veoma oštре polemike svuda u svetu.

and to mark humans has initiated severe criticism and disputes all over the world. Human rights protection organizations, Christian communities, a majority of academic circles and many others have said *no*. It is to be expected that the RFID technology will continue developing and advancing and that it will be used in all business systems that serve mankind. Beyond these limits, there can be found no justification for RFID technology applications.

Svoj glas protiv su rekle organizacije za zaštitu ljudskih prava, hričanske zajednice, veliki deo akademske javnosti, i mnogi drugi. Može se očekivati da će RFID tehnologija i dalje imati intenzivan razvoj, napredak i primenu u svim poslovnim sistemima, koji služe čoveku. Van tih granica primena ova tehnologije nema opravdanja.

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