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Design and Analysis of Open and Closed Loop Supply Chain Distribution Network Using K-Means Cluster Based Algorithm and Simulated Annealing Techniques

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ABSTRACT: Short for radio frequency identification, RFID is a dedicated short-range communication technology. The term RFID is used to describe various technologies that use radio waves to automatically identify people or objects. RFID is a method of remotely storing and retrieving data using RFID tag. Radio Frequency Identification (RFID) technology has been attracting considerable attention with the expectation of improved supply chain visibility for consumer goods, apparel, and pharmaceutical manufacturers, as well as retailers and government procurement agencies. It is also expected to improve the consumer shopping experience by making it more likely that the products they want to purchase are available. Recent announcements from some key retailers have brought the interest in RFID to the forefront. This guide is an attempt to familiarize the reader with RFID technology so that they can be asking the right questions when considering the technology. RFID technology is used today in many applications, including security and access control, transportation and supply chain tracking. Referring to such scenario, in this work RFID Technique adopted to optimize open loop supply chain distribution network and analyzed the results with K-Means Cluster based Algorithm with real time case study of water can distribution logistics system.

KEYWORDS: RFID, Supply Chain Distribution Network, Open Loop Supply Chain,

I. INTRODUCTION

Radio Frequency Identification (RFID) is a technology which allows contact less access to data on a transponder (also called tag or chip). Already in the late forties of the last century RFID was used to identify friendly aircraft. In 1948, Stockman described the base of RFID in his seminal article "Communication by Means of Reflected Power". Ongoing miniaturization and advancements in technology have lead to smaller and cheaper tags, which have made widespread use of RFID possible in supply chains. The benefits of RFID in supply chains are well documented. Large retailers, e.g. Wal-Mart and the Metro Group as well as large consumer goods producers like Procter & Gamble and Unilever, are amongst the early adaptors of the technology. Defence Departments also expect significant efficiency gains and cost reduction for their Military Logistics Operations. Better stock keeping, reduced shrinkage, improved tracking, better information flows along the supply chain and a higher service level are some of the benefits attributed to the introduction of RFID.

RFID is sometimes presented as a more sophisticated barcode or simply as the natural evolution from a paper-based to an electronic auto-ID technology. This analogy is dangerous, as it could result in inadequate risk management of RFID projects and systems. If not addressed, the specific nature of RFID, namely the wireless interface and the small computational footprint, might lead to security problems. The risks of RFID implementations are often solely seen as a consumer privacy problem, which can be dealt with at the point of sale by deactivating the tags. However, RFID specific security risks such as information leakage and data inconsistency arise along the entire supply chain. Ignoring



the RFID specific risks in a supply chain environment can become quite costly. A preliminary consideration of the security risks is a prerequisite to achieve a successful RFID implementation. Rather surprisingly, the security implications of RFID projects for the supply chain are rarely addressed in a structured manner, but, if at all, on an ad hoc basis. The remainder of the paper is organized as follows. First, we give a brief introduction to Supply Chain Management (SCM) and RFID, as well as to RFID specific supply chain setups. We explore the possible relations between benign and malicious RFID-readers as well as genuine and forged tags. Furthermore, we outline a number of possible attacks on the settings discussed and their respective impact on the supply chain operations. The implementation difficulty and the benefits for the attacker build the base for the RFID risk classification. Finally, we derive practical recommendations regarding risk management in RFID supported supply chains.

1.1. RFID systems

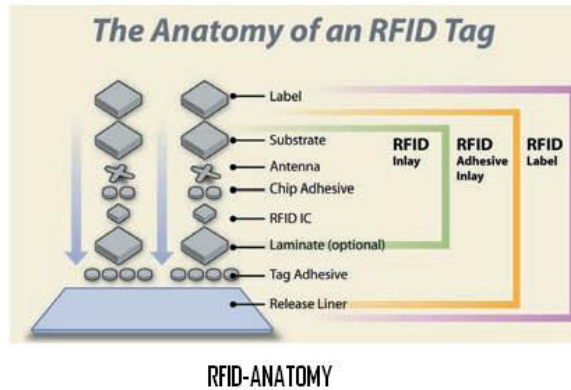
In a typical system tags are attached to objects. Each tag has a certain amount of internal memory (EEPROM) in which it stores information about the object, such as its unique ID (serial) number, or in some cases more details including manufacture date and product composition. When these tags pass through a field generated by a reader, they transmit this information back to the reader, thereby identifying the object. Until recently the focus of RFID technology was mainly on tags and readers which were being used in systems where relatively low volumes of data are involved. This is now changing as RFID in the supply chain is expected to generate huge volumes of data, which will have to be filtered and routed to the backend IT systems. To solve this problem companies have developed special software packages called savants, which act as buffers between the RFID front end and the IT backend. Savants are the equivalent to middleware in the IT industry.

1.2 RFID Tags

At the heart of any RFID system is the tag, also known as the transponder. Two types of tags and their variants – active and passive – dominate the marketplace and are designed for specific applications. Active tags are battery powered with on-board battery power sources, contain up to hundreds of kilobytes of memory and can communicate data over longer ranges than passive tags. The tags are always on and always talking. Active tags, especially because of the built-in batteries, are far more expensive than passive tags. Active tags have been used for years and are typically used in long-range tracking applications and to track high-value inventory.

ACTIVE TAGS	PASSIVE TAGS
Battery Powered	Beam Powered ¹
100's of KB Memory	64 — 256 bits Memory
Expensive	Inexpensive
Limited Battery Life	Long Life
Active Transmit	Backscatter ² Transmit
Long Range	Short/Medium Range
Tag Talks First (TTF)	Reader Talks First (RTF)

Companies managing their supply chains primarily focus on passive UHF RFID tags. These passive tags, because their low cost and relatively long read ranges (up to 25 feet), offer the best performance/value ratio across the supply chain. Passive tags communicate with readers leveraging backscatter technology and are “beam powered”, meaning they derive all of their operational power from the RF environment. The RFID reader generates a radio signal and broadcasts it via the connected antenna configured in a radio frequency (RF) field. A tag, with an on-board antenna senses the radio signal and is energized; releasing its preprogrammed data and reflecting it back to the reader via a modulated radio signal. The reader then decodes the reflected signal, aggregates the data and passes the data to the host system. It all happens in an instant. Physically, passive RFID tags are made up of a semiconductor chip attached to a printed antenna and mounted on a substrate, such as Mylar or plastic. The type and design of the substrate, antenna and chip depends on the application.



II. SUPPLY CHAIN MANAGEMENT

The supply chain is a complex multi-stage process which involves everything from the procurement of raw materials used to develop products, and their delivery to customers via warehouses and distribution centers. Supply chains exist in service, manufacturing and retail organizations. Although, the complexity of the chain may vary greatly from industry to industry and firm to firm. Supply chain management (SCM) can be seen as the supervision of information and finances of these materials, as they move through the different processes, by coordinating and integrating the flows within and among the different companies involved. The efficiency of the supply chain has a direct impact on the profitability of a company. It is no surprise therefore to find that many large corporate companies have made it a key part of their strategy, and invested heavily in software systems (ERP, WMS.) and IT infrastructure designed to control inventory, track products and manage associated finance.

2.1. SUPPORTING TECHNOLOGIES FOR SUPPLY CHAIN MANAGEMENT

2.1.1. Agent Technology

Agent Link, the European Co-ordination Action for Agent Based Computing, defines agents as "autonomous, problem-solving computational entities capable of effective operation in dynamic and open environments" (Luck et al. 2003, p. 10). Platforms that support several autonomous agents and their interactions are called Multi-Agent-Systems (MAS). The characteristics of agents (e.g. autonomy, pro-activity or adaptively) lend themselves to model, simulate and realize distributed supply networks. Thus, agents have been successfully applied to a variety of supply network processes such as production planning, scheduling and transportation

2.1.2. Mobile Computing Technology

Through third-generation mobile networks (e.g. UMTS) data transfer rates are now available theoretically up to 2 MBit/s. Nevertheless, in today's enterprises the use of mobile devices such as mobile phones or smart phones is often limited to make calls and to use the short message service although today's mobile phones still support Java- or WAP-based applications. Beyond data transfer rates enterprises are often concerned about security, service continuity and cost. With *Mobile IPv6*, for example, the implementation of strong authentication and encryption features (IP Security) will improve security in mobile networks. Furthermore, a unique static IP address can be assigned to the mobile device, so ubiquity and seamless roaming will be possible within supply networks.

2.1.3. Auto-ID Technology

For tracking & tracing resources along supply networks Auto-ID technology plays an important role. The Auto-ID technology developed by the Auto-ID Center consists of the following components combined in the EPC network

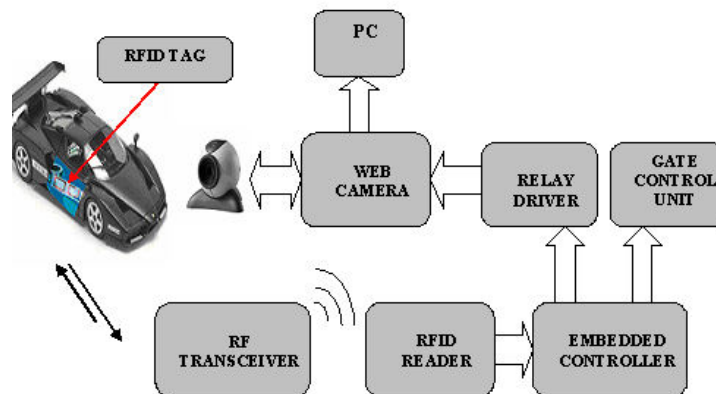
- **Radio Frequency Identification (RFID) tags and readers:** A tag is only a few square millimeters in size and is made up of a chip and an antenna. It can be scanned by special readers from a distance up to some meters dependent on the technology used.
- **Electronic Product Code (EPC):** EPC as the core of the EPC network is used for identification of physical objects in the real world. The Auto-ID Center released several different versions. The most common one is a 96-bit version with two different formats (General-Identifier and Serialized-General-Trade-Item-Number).

- **Object Naming Service (ONS):** ONS is a look-up service that delivers one or several IP addresses to the identified EPC.
- **Savant:** Savant acts as middleware that integrates the other components. The main functions are transmitting, filtering and bundling incoming data streams from readers to other services like ONS or existing enterprise applications.
- **Physical Markup Language (PML):** PML is a XML-based markup language to describe physical objects for standardized data exchange between the components of the EPC network.
- **EPC Information Service:** This service delivers product-related data of the observed objects.

III. APPLICATION OF RFID IN SCM

RFID provides a quick, flexible, and reliable electronic means to detect, identify, track, and manage a variety of items. The technology is well-suited for many operations in all types of industries provided that users develop new business processes to take advantage of RFID’s special abilities. Merely substituting RFID for bar coding will not give users all the benefits that the technology could provide. Many potential users of RFID technology try to make comparisons between the relative cost of RFID and bar code, when comprehensive business process return on investment (ROI) analyses should be conducted. In recent years, interoperable products have emerged, helped by renewed standards efforts by EPC global and other standards bodies. In addition, major systems integrators have introduced RFID offerings and products that can make the adoption of RFID, especially in the enterprise, more straightforward as they build on existing and familiar systems. These efforts have enabled many companies to implement RFID pilots in their organizations and begin to calculate the ROI this technology can bring to their operations.

Block diagram



3.1. Specifications:

Embedded Controller:

Device Name : P89C51RD2BN
 Operating Voltage : 4.5 – 5.5 V
 ROM : 64KB
 RAM : 1KB
 Crystal Frequency : 11.0592 MHz
 Time taken for execution: 1.085µs

RFID Reader:

Frequency : 125 kHz
 Operating Voltage : 5V DC (± 5 %)
 Read Range : up to 3 cm

Serial Interface

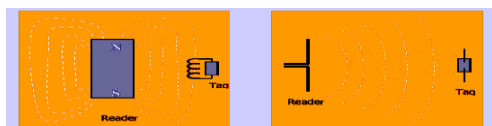
Format : 9600Baud, No Parity, 8 Data bits, 1 Stop bit

Web Camera:

I/O interface : USB
 Operating Voltage : 3.3 V

3.2. Techniques used in RFID

The region or air interface between a tag and an interrogator (reader/programmer) constitutes what is known in communication terms, as a channel. The channel is fundamental to the process of communication. It can be viewed as the transmission pathway or medium through which information (or data) can be expected to flow, in conveying it from its source to its destination. Communication of data between a tag and an interrogator (reader/programmer) is by wireless communication. Two methods distinguish and categorize RFID systems, one based upon close proximity electromagnetic or **inductive coupling** and one based upon electromagnetic backscatter or **propagation coupling**. Two ways of energy and information transfer between reader and tag.



Magnetic field (near) Inductive coupling Electric field (far field) Backscatter

Coupling is via 'antenna' structures forming an integral feature in both tag and interrogator (reader/programmer).

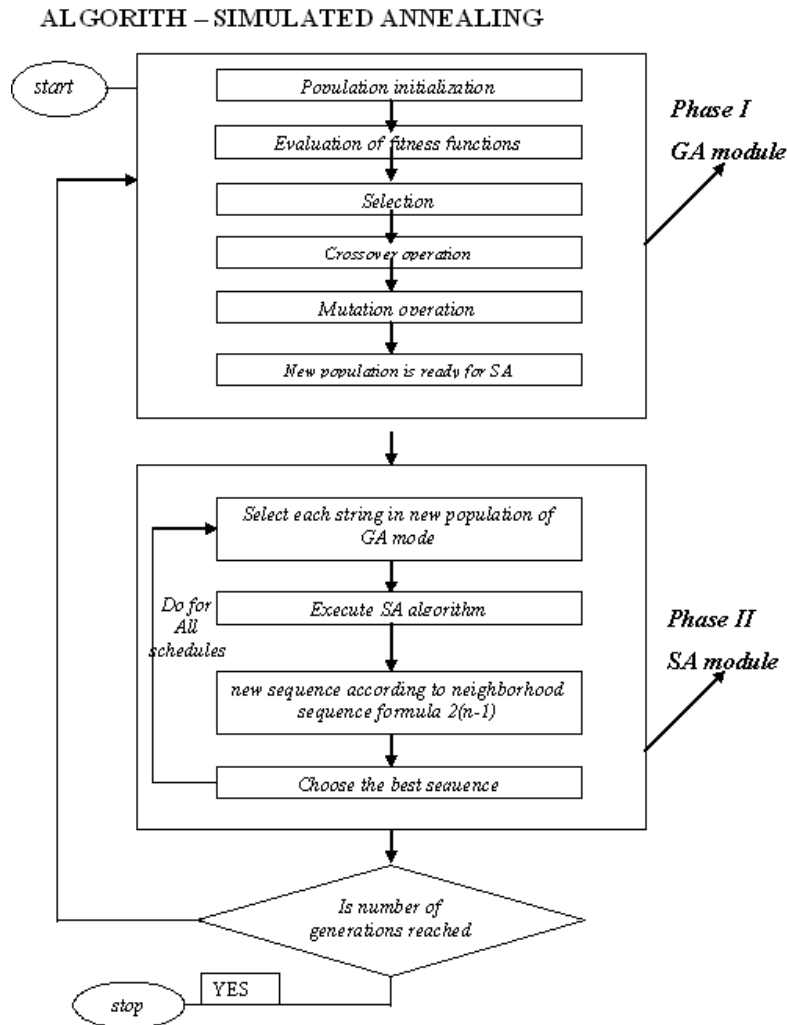
IV. OPEN LOOP SUPPLY CHAIN DISTRIBUTION NETWORK

A salesman has to visit n cities and return to his city of origin. Each city has to be visited exactly once, and the distance (or more generally the cost) of the journey between each pair of cities is known. The problem is to do the tour at minimum total cost. This forms one of a class of problems known as NP- complete problems, which are believed to require a computation time $\exp(kn)$, where k is a constant of the problem, and n is the number of cities for an exact solution. precisely, TSP can be interpret as follows: given a finite number of “ cities” along with the cost of travel between each pair of them, find the cheapest way of visiting all the cities and returning to your starting point. A common special case of the TSp is the metric TSP, Where the distances between cities satisfy the triangle inequality. It means that there is little hope foe us to solve it in polynomial time unless $P=NP$.

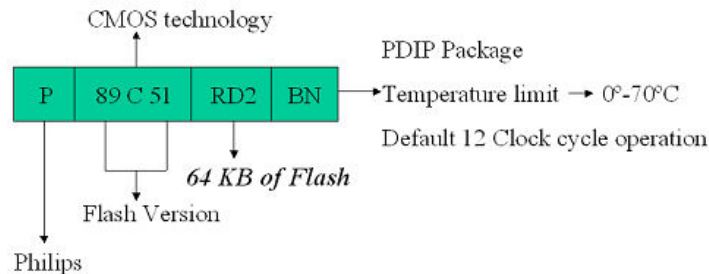
The TSP has been studied with much interest within the last three to four decades. The majority of these works focus on the static and deterministic case of vehicle routing in which all information is known at the time of the planning of the routes. In most real –life applications though, stochadtic and /or dynamic information occurs parallel to the routes being carried out. Real – life examples of stochastic and /or dynamic routing problems include the distribution of oil to private house holds, the pick-up of courier mail/packages and the dispatching of buses for the transportation of elderly and handicapped people. In these examples the customer profiles (i.e. the time to begin service, the geographic location, the actual demand etc.) may not be known at the time of the planning or even when service has begun for the advance request customers. Two distinct features make the planning of high quality routes in this environment much more difficult than it its deterministic counterpart; firstly, the constant change, secondly, the time horizon. A growing number of companies offer to service the customers within a few hours from the time the request is received. Naturally, such customer service oriented policies increase the dynamism of the system and therefore its complexity. During the past decade the number of published papers dealing with dynamic transportation models has been growing. A simple but effective algorithms GA. SA, Hybrid GA-SA, K- Means Cluster based heuristic, Hybrid K- Means Cluster based heuristic- GA and Hybrid K- Means Cluster based heuristic – GA- SA for



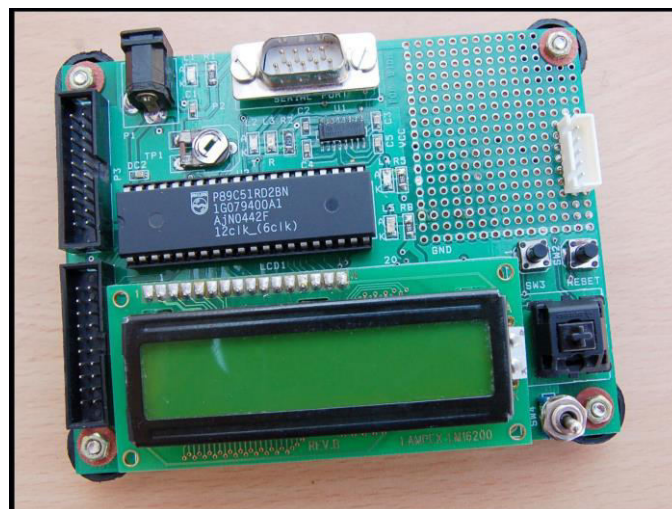
ATSP is proposed in this thesis. The problem of minimizing the distance traveled from center single depot to all given n cities are considered as the objective function for ATSP. GA has been modified by incorporating the uniform crossover operator and double operator crossover operator namely uniform crossover operator and swap crossover operator in the crossover process. The modified GA is compared with general GA and the modified is proved better obtaining nearer optimal solutions for ATSP.



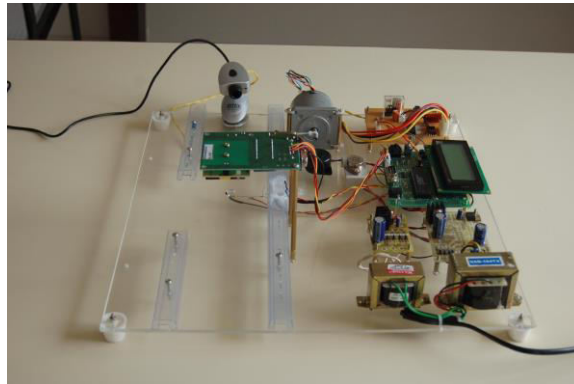
V. RFID ARCHITECTURE - EMBEDDED MICROCONTROLLER – P89C51RD2



The P89C51RD2BN contains a non-volatile 64KB Flash program memory that is both parallel programmable and serial In-System and In-Application Programmable. In-System Programming (ISP) allows the user to download new code while the microcontroller sits in the application. In-Application Programming (IAP) means that the microcontroller fetches new program code and reprograms itself while in the system. This allows for remote programming over a modem link. A default serial loader (boot loader) program in ROM allows serial In-System programming of the Flash memory via the UART without the need for a loader in the Flash code. For in-application Programming, the user program erases and reprograms the Flash memory by use of standard routines contained in ROM. The device supports 6-clock/12-clock mode selection by programming a Flash bit using parallel programming or In-System Programming. In addition, an SFR bit (X2) in the clock control register (CKCON) also selects between 6-clock/12-clock mode. Additionally, when in 6-clock mode, peripherals may use either 6 clocks per machine cycle or 12 clocks per machine cycle. This choice is available individually for each peripheral and is selected by bits in the CKCON register. This device is a Single-Chip 8-Bit Microcontroller manufactured in an advanced CMOS process and is a derivative of the 80C51 microcontroller family. The instruction set is 100% compatible with the 80C51 instruction set. The device also has four 8-bit I/O ports, three 16-bit timer/event counters, a multi-source, four-priority-level, nested interrupt structure, an enhanced UART and on-chip oscillator and timing circuits. The added features of the P89C51RD2BN make it a powerful microcontroller for applications that require pulse width modulation, high-speed I/O and up/down counting capabilities such as motor control. When the 89C51 microcontroller is connected to a crystal oscillator and is powered up, we can observe the frequency on the XTAL2 pins using the oscilloscope.

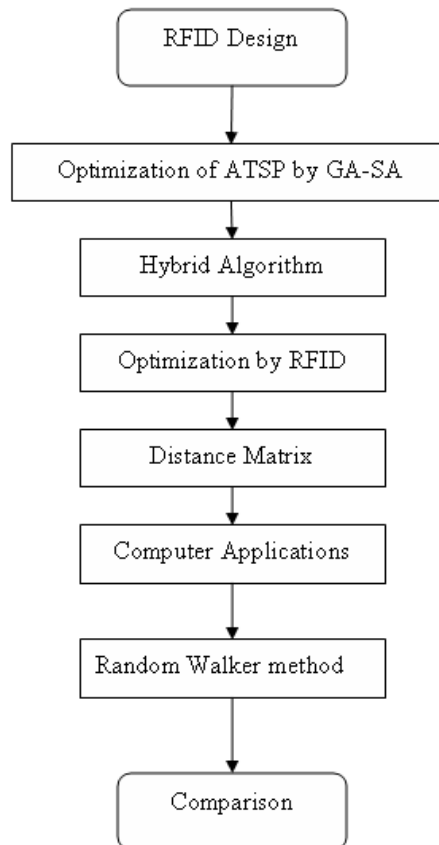


Display System in Circuit Design



Circuit Design of RFID System for Effective Supply Chain Management

VI. OPTIMIZATION OF SCM NETWORK BY RFID:



VII. CONCLUSIONS

RFID is a stable automatic identification technology that holds great promise for improving business processes; its use is becoming increasingly widespread. Indeed, some early adopter companies applying RFID at the carton and case level to mixed merchandise to automate creation of receiving and shipping manifests, have observed that RFID gives them unexpected opportunities to perform goods handling processes in efficient, entirely different ways. RFID should be considered for any application that could realize a clear benefit in terms of efficiency, reduced loss, or improved service. RFID offers strong performance and functionality, but at a price—considering tags relative to simple labels. The added cost of RFID, weighed against bar codes’ outstanding value and the enormous installed, working infrastructure ensures the two technologies will coexist, just as our nation’s roads are still full of cars despite the



growth of commercial air travel during the last 50 years. Because RFID tags can be reusable, don't require line of sight to read or write, enable unattended reading, and offer read/write data storage, they can improve efficiency in many operations by reducing labor and materials costs. Potential users must carefully evaluate the long-term impact for improved business operations relative to total cost of ownership and not automatically rule out use of the technology because of the initial investment required.

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