DESIGN, OPERATION AND ANTI-COLLISION PROCEDURE OF DATA TRANSFER OF INTELLIGENT LOAD UNITS

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Abstract: The difference between an intelligent unit load and conventional counterparts is a unit of cargo-handling device, which is transmitted from a cargo box to a transport box through a container. This is a built-in artificial intelligence with which the cargo, cargo-critical physical, chemical and biological parameters are continuously monitored. The article introduce a new concept of intelligent unit load and with it a new electronics - computer system, its construction and the phases of the technical operation are presented. An overview is provided about the anti-collision method used in practice and a possible theoretical new anticollision method for this special new field is presented. This article presents also the benefits of intelligent unit loads in logistic applications.

Keywords: intelligent unit load, multi-access procedures, anticollision method

1. Introduction

Within the logistics process transportation of the goods are exposed to various stresses. The complexity of the processes increases the probability of the damage of the transported goods, therefore causing less profit for their respective companies.

1.1. Intelligent unit load. The intelligence and the unit load can be constructed concepts which is the intelligent cargo unit load concept. The difference between an intelligent unit load and conventional counterparts is a unit of cargo-handling device, which is transmitted from a cargo box to a transport box through a container, built-in artificial intelligence (small electronic embedded system) of cargo. A lot of cargo-critical physical, chemical and biological parameters are continuously monitored by the system, if the predefined critical levels are exceeded, an alarm gives off. Their structure in accordance with other various so-called server tasks, which are the administrative tasks of quality assurance tasks, through either positioning can spread, so it can be complex task. If so, they support the logistics, material flow requirements for quality assurance, and the production or service activity, that there must be a variety of different products required, and the flow of material associated with this information collection, storage, evaluation and use of quality assurance [1].

1.2. Design of intelligent unit loads. *Figure 1.* shows the intelligent supply chain of unit load specific section of the applicability of the field. We examined the design of the product delivered to the place of departure, destination and arrival phase.

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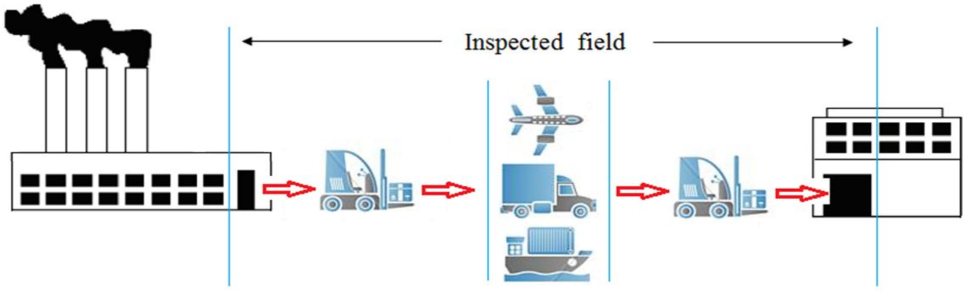

Figure 1. The goods examination
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In practice the diversity of goods has to be considered because of the goods harmful parameters, these parameters have to be stored in intelligent unit loads before they come to a critical level. *Figure 2.* shows the construction principle of such a system.

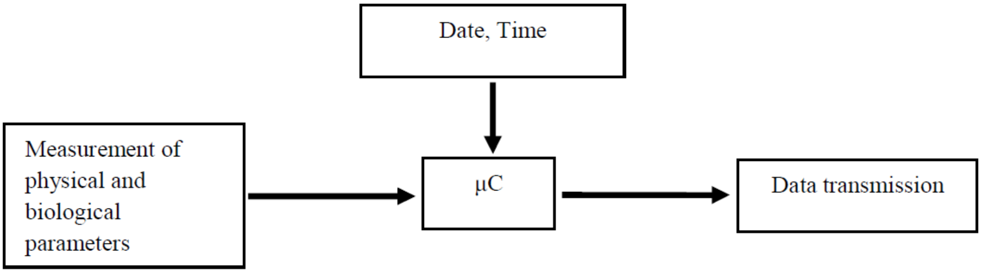

Figure 2. Conceptual structure of a system.
Source: own compilation

The generally measured physical and biological parameters are: mass, temperature, pressure, humidity, acceleration, light intensity, UV radiation, radioactive radiation, proximity, chemical, biological contaminants such as molds, microtoxins etc. Determining the quality of the goods, can be measured using modern technology.

The main task of an intelligent unit load is continuous automatic data collection and evaluation. Using automatic data collection we get much more reliable data available for logistics management. This way they are better enforced the logistics objective function: the minimum lead time, minimum stock, minimum effort for maximum customer satisfaction, etc.. This process can be seen better through a specific example. Before the process you must know the type of delivered goods, the quantity of the goods, the harmful parameters and the critical levels of these parameters. For example, if we want to deliver 100 mobile phones in a unit load, then we have to know what level of the temperature, vibration and shock can adversely affect the goods quality. In addition, we know the total weight of the goods. These parameters go into the intelligent unit loads, during the entire process, these parameters have to be continuously monitored. In addition, an example, capacitive sensor continuously monitor, that there is no person or animal approaching the load. If the activated temperature sensor signal value is too high, which may lead to loss of good quality, then this signal is transmitted with the current date and time to a logistics center. If the weight sensor indicates that the cargo has reduced weight, then it can be concluded that the goods were taken off cargo. In this case, the time, date and GPS coordinates will be immediately forwarded. This information can greatly facilitate the detection of offenders.

The most important components of an intelligent unit load:

- Compartment, plastic pallets,
- Transducer,
- Energy Management,
- Microprocessor, or micro controller,
- Memory,
- Sensor Unit, the physical - chemical and biological parameters measurement,
- Date, Time, clock,
- RF-ID Antenna,
- GSM Antenna,
- GPS Antenna.

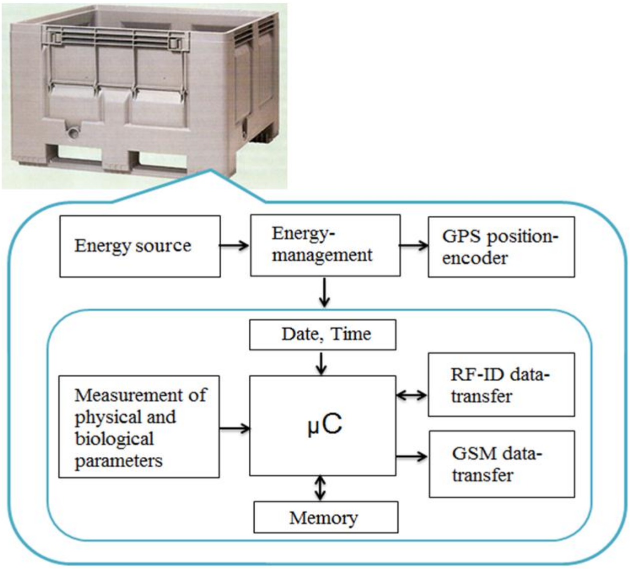

Figure 3. Intelligent unit load block diagram
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The information obtained shall be forwarded to the destination of the goods, which can be a logistics distribution center, factory or store. Modern technology make the data transmission a proven solution. For large, intercontinental distances, satellite communications are used. Smaller countries within a continent we consider a simple GSM network for data transmission. The latter method has the advantage of low cost, and the transferred amount of data and information contained within narrow limits is moving, because only in case of alarm data has been transferred, with the help of a short message (SMS), which contains 160 characters.

2. The phases of system operation

2.1. Preparation. Profile of the product. The size, weight, packaging, adverse effects and the maximum amount of the goods is given.

2.2. The programing of an intelligent unit load. The goods parameters for example: type of goods, quantity, weight, date, time and issuing station, entering destinations. The monitored parameters for example: temperature, gravity, radiation, or theft detection, notification. The product is provided with an identification number. They activate the electronics.

Figure 4. Intelligent unit load programing
Source: Own compilation, the source of the graphic elements is the Internet

These data are automatically uploaded by either using a handheld terminal or, for example by using the last stage of a manufacturing process.

2.3. The loading of a unit. Before delivery by using a hand-held terminal unit, with a touch of a button all the cargo products ID will be transferred. This information has the same ID as the transportation tool for example: a truck. The transport operator checks this data and the transfer / transfer is completed. The resulting data is loaded to the central data bank.

Figure 5. The loading of a unit
Source: own compilation, the source of the graphic elements is the Internet

2.4. Transport. During transport the intelligent unit loads are actively guided by regular intervals for the parameters to be measured. If one of the measured parameters causes a problem, emergency alarms will be triggered.

2.5. Takeover of goods. Using a hand-held terminal, all of the intelligent unit loads electronics require identification and all of the monitored quality parameters scanned by a single push of the status button. By a person performing, supplying the data, the first quality test started.

Figure 6. Takeover of goods
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3. Multi-access procedures – anti-collision

The communication of an intelligent unit load is shown on *Figure 3*.

Radio Frequency Identification (RFID) systems use radio frequency to automatically identify products. There are two parts in the RFID system, Reader and Tag. The RFID system can be classified into the active RFID (Tag with battery) system and the passive RFID (Tag without battery) system.

The different transmission frequencies are classified into the four basic ranges, LF (low frequency, e.g. 125KHz), HF (high frequency, e.g. 13.56MHz), UHF (ultra high frequency, e.g. 868MHz or 915MHz) and microwave (e.g. 2.4GHz). For LF and HF RFID, the read range is usually less than 60cm. For microwave RFID, because of the sensitivity to the environment, the maxim reader range is about 1m. For UHF RFID, the read range can generally reach to 5m. So the application of UHF RFID is more and more popular. In this paper, only the passive UHF RFID systems will be discussed. Because the distance between reader and tag increases, the reader should identify many tags at simultaneously.

The operation of RFID systems can involves a situation in logistics in which numerous transponders are present in the interrogation zone of a single reader at the same time. In such a system — consisting of a ‘control station’, the reader, and a number of ‘participants’, the transponders — we can differentiate between two main forms of communication.

The use of an intelligent unit load in many cases is resulting, such as delivery, or to reduce lead times, that we need to request information from a reader.

First, the data transmitted from a reader to the transponders (*Figure 7.*). The transmitted data stream is received by all transponders simultaneously. This is comparable with the simultaneous reception by hundreds of radio receivers of a news programme transmitted by a radio station. This type of communication is therefore known as *broadcast* [5].

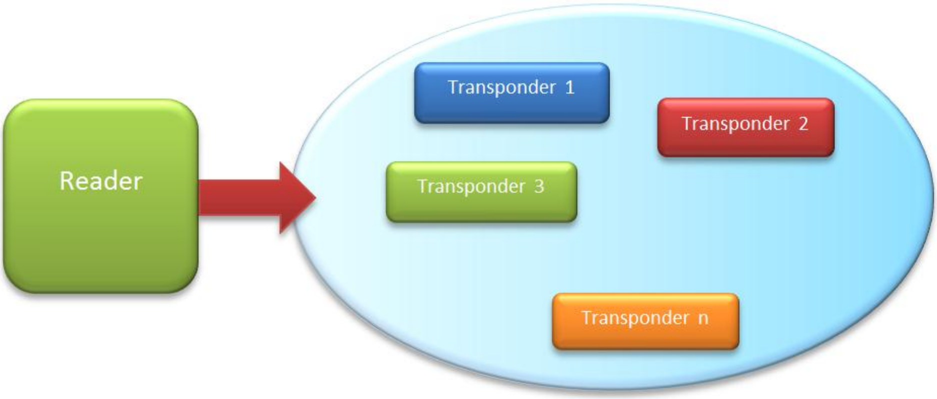

Figure 7. Broadcast mode: the data stream transmitted by a reader is received simultaneously by all transponders in the reader's interrogation zone. Source: own compilation

The second form of communication involves the transmission of data from many individual transponders in the reader's interrogation zone to the reader. This form of communication is called *multi-access* (*Figure 8.*).

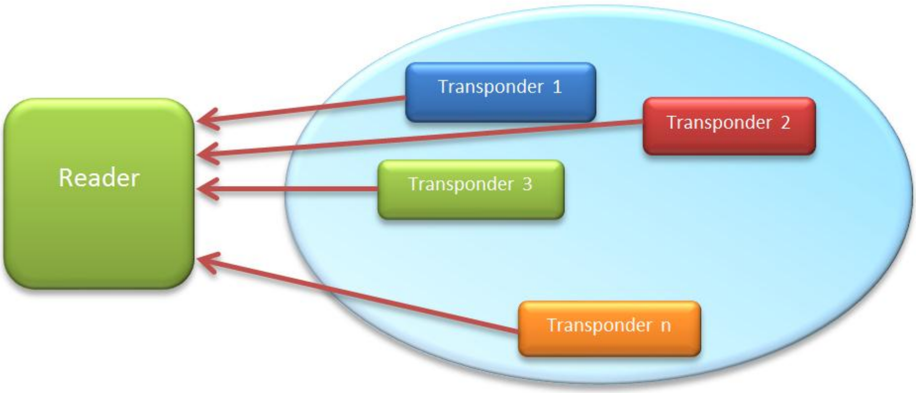

Figure 8. Multi-access to a reader: numerous transponders attempt to transfer data to the reader simultaneously. Source: own compilation

Every communication channel has a defined channel capacity, which is determined by the maximum data rate of this communication channel and the time span of its availability. The available channel capacity must be divided between the individual participants (transponders) such that data can be transferred from several transponders to a single reader without mutual interference (collision).

In an inductive RFID system, for example, only the receiver section in the reader is available to all transponders in the interrogation zone as a common channel for data transfer to the reader. The maximum data rate can be calculated from the effective bandwidth of the antennas in the transponder and reader. The problem of multi-access has been around for a long time in radio technology. Examples include news satellites and mobile telephone networks, where a number of participants try to access a single satellite or base station.

For this reason, numerous procedures have been developed with the objective of separating the individual participant signals from one another. Basically, there are four different procedures (*Figure 9.*): *space division multiple access (SDMA), frequency domain multiple access (FDMA), time domain multiple access (TDMA)* and *code division multiple access (CDMA)*, otherwise known as *spread-spectrum*. However, these classical procedures are based upon the assumption of an uninterrupted data stream from and to the participants [6], once a channel capacity has been split it remains split until the communication relationship ends (e.g. for the duration of a telephone conversation).

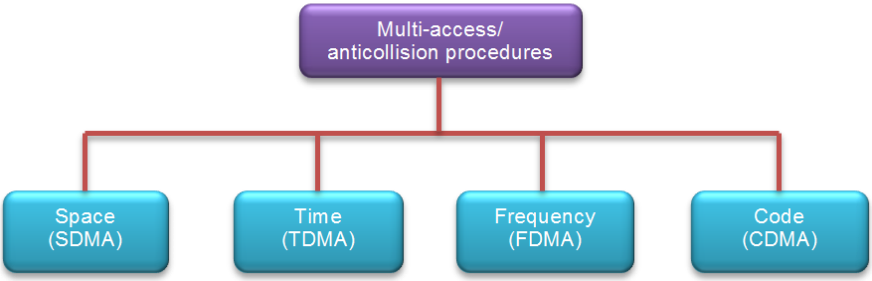

Figure 9. Multi-access and anti-collision procedures are classified on the basis of four basic procedures. Source: own compilation

RFID transponders, on the other hand, are characterised by brief periods of activity interspersed by pauses of unequal length. A contactless smart card in the form of a public transport travel card, which is brought within the interrogation zone of a reader, has to be authenticated, read and written within a few tens of milliseconds. There may follow a long period in which no smart cards enter the reader's interrogation zone. However, this example should not lead us to the conclusion that multi-access is not necessary for this type of application. The situation in which a passenger has two or three contactless smart cards of the same type in his wallet, which he holds up to the antenna of the reader, must be taken into account.

A powerful multi-access procedure is capable of selecting the correct card and deducting the fare without any detectable delay, even in this case [6]. Channel capacity is only split for as long as is actually necessary (e.g. during the selection of a transponder in the reader's interrogation zone).

The technical realisation of a multi-access procedure in RFID systems poses a few challenges for transponder and reader, since it has to reliably prevent the transponders' data (packages) from colliding with each other in the reader's receiver and thus becoming unreadable, without causing a detectable delay. In the context of RFID systems, a technical procedure (access protocol) that facilitates the handling of multi-access without any interference is called an *anti-collision system*.

The fact that a data packet sent to a reader by a single transponder, e.g. by load modulation, cannot be read by all the other transponders in the interrogation zone of this reader poses a particular challenge for almost all RFID systems. Therefore, a transponder cannot in the first instance detect the presence of other transponders in the interrogation zone of the reader. **For reasons of competition, system manufacturers are not generally prepared to publish the anti-collision procedures that they use.** A number of different methods are in use and in development today for preventing collisions, but all are related to making sure that only one tag "talks"at any one time. These methods are referred to anti-collision algorithms.

There are many protocols about UHF RFID, such as EPC Class1, EPC Class1 Generation 2 (abbreviate as Gen2) and ISO 18000-6.

3.1. Anti-collision algorithms. For anti-collision algorithms in RFID systems, ALOHA and Binary Tree algorithms are most widely used. Both of them are based on TDMA method. The reader command is divided into several slots. When there is only one tag responses in one slot, reader can identify the tag correctly. For ALOHA algorithm, there are many advanced versions, for example, Slotted ALOHA, Framed Slotted ALOHA and Dynamic Framed Slotted ALOHA.

3.1.1. ALOHA. ALOHA algorithm is a simple anti-collision method based on TDMA. When the tag reaches the interrogation area of a reader, the tag will transmit the data immediately, and when more than one tag response at the same time, the collision occurs. So the most disadvantage of this algorithm is the high probability of collision.

3.1.2. Slotted ALOHA. In Slotted ALOHA algorithm, the time is divided into several slots, and the tag must transmit data in one slot which it selects. So this method will decrease the probability of collision than ALOHA algorithm, but the reader and tag must communicate synchronously. When there is only one tag in one slot, reader can interrogate with tag and require the information of tag correctly. Due to the limitation of the number of slots, this algorithm used in the case that there are a few tags in the area.

3.1.3. Framed Slotted ALOHA (FSA). In FSA algorithm, one frame consists of several slots, and the tag will choose one slot in a frame to transmit data. FSA algorithm uses a fixed frame size and does not change the size during the process of tag identification. In FSA algorithm, the frame size is decided by the reader. Tags generate a random number that is used to select a slot in one frame and each tag then response in the slot it selected. Reader will identify tags with multiple frames, so it can solve the problem in slotted ALOHA algorithm. Since the frame size of FSA algorithm is fixed, its implementation is simple, but it has a weakness that drops efficiency of tag identification. For example, in FSA algorithm, when the number of tags is small, it should choose a small number of slots in one frame, or it will cause waste of empty slots; when the number of tags is large, it should choose a large number of slots in one frame, or there will be too many collisions and it will take a long time to identify all tags.

3.1.4. Dynamic Framed Slotted ALOHA (DFSA). DFSA algorithm changes the frame size for tag identification. So DFSA algorithm is more efficient than FSA algorithm to identify tags. Because of different methods to modify the frame size, DFSA algorithm has several versions. To determine the frame size, it uses the information such as the number of slots used to identify the tag and the number of the slots collided and so on. For example, when the number of the slots collided is larger than the upper limit, reader will add the number of slots in one frame, when the number of the empty slots is smaller than the lower limit, reader will decrease the number of slots in one frame. DFSA algorithm has more advantages than other ALOHA-type algorithms, so it is most widely used.

3.2. New anti-collision method. The use of an intelligent unit loads in logistics is an important requirement, that the systems containing unknown number of transponders can change data in the shortest time possible. This procedure can occur during cargo delivery, customs inspection.

Since the current ID and the number of transponders for the system are unknown, the presented procedures can not be used safely. One of the first needs of the algorithm might look like this. The master software can isolate "x" memory of RAM space and then send the data requesting command. The slave's Requests for information receive the command and they will start generating a transaction number, which number - "z" step by step to add value. The z value must be greater than the time required to transmit information carried forward in a millisecond. The slave's send their ID by generating their own transaction number with some delay. The master returned the IDs stored in each of the x-numbered memory. If the x-numbered memory is not full, then by knowing the IDs the master addresses the transponders one by one.

If the "x" number of memory is full, then by increasing the "x" number of memory the process begins again until the ID is less than how much memory there was reserved.

4. The intelligent unit loads logistic aspect

The intelligent unit loads logistic advantages include:

- The continuous monitoring of the goods and the physical and biological parameters of the surrounding environment can help to achieve the "0" error strategy in the supply chain,
- The rules of the logistics realized more effectively,
- Precise knowledge of amount of goods,
- Qualitative differences,
- With an appropriate sensor, at the right place, the fixation of the load can be properly examined,
- 100% of the goods will be observed,
- Continuous monitoring,
- In case of damage under proper construction, forecast (in special cases, slow processes),
- Identification tasks, extended identification options,
- Manual quality control becomes unnecessary,
- Major simplification of administrative tasks,
- Real-time information about the differences,

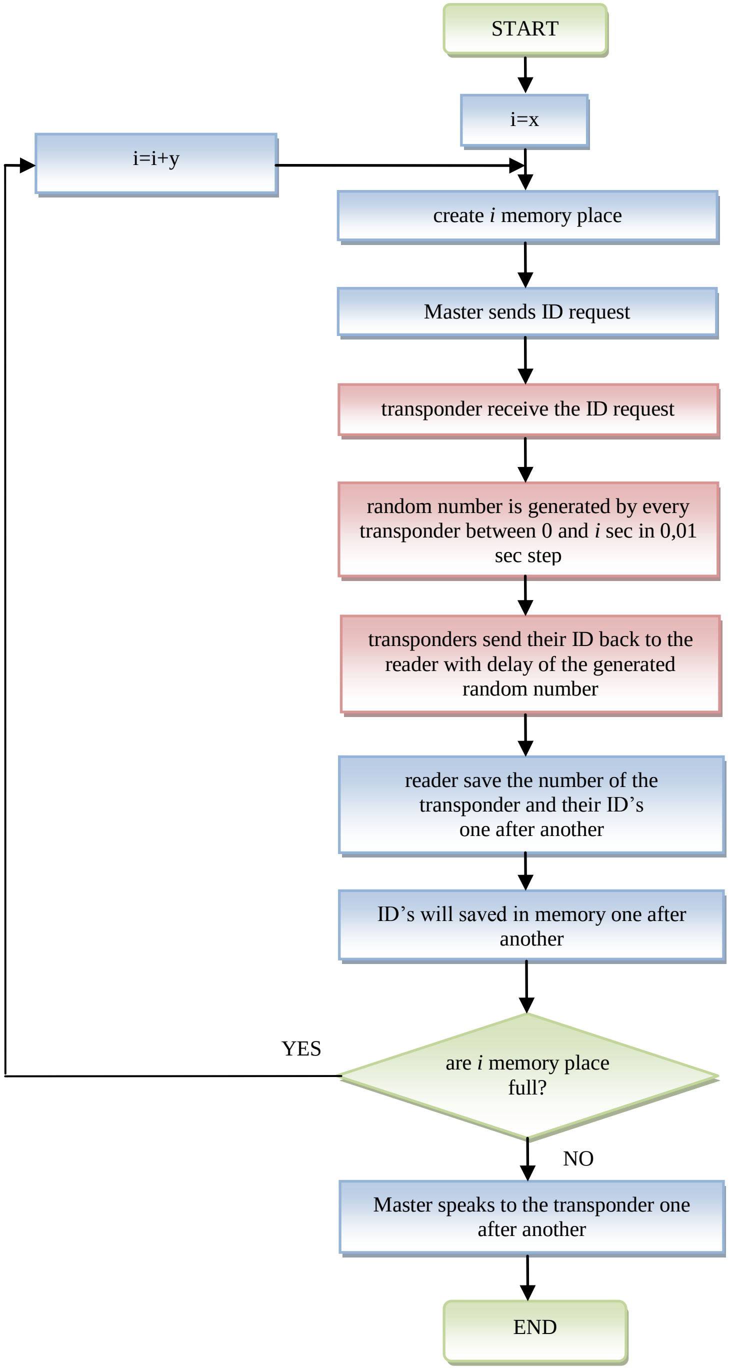

Figure 10. Flowchart of the anti-collision algorithm.
Source: own compilation

- Loading, transport during the human, - accidental or intentional omissions, technical problems with the registration and transmission of logistics center
- Receiving goods - major simplification in the transfer
- Lowering quality inspection cost, simplifying,
- Customs / Customs and Finance Guard simplification studies
- Hazardous materials such as. chemical, or transport of radioactive materials can be checked that is not dangerous to the environment,
- In case of theft of any immediate knowledge of the place and time,
- Clarification of legal issues to facilitate,
- Specific transport section survey stresses occur → optimization of packaging, etc.

Urgent measures will be applied in case of alarm, for example:

- The defective goods do not have be delivered to the warehouse inventory → resources,
- Complaint cases conducted immediately commenced,
- JIT system, to reduce possible downtime, new goods can be instantly ordered,
- Quality Assurance and the need to take legal action becomes unnecessary,
- Selection of suppliers and transportation company promotion.

5. Outlook

The intelligent unit loads construction due to the diversity of the logistics can be widely applied. In this article the concept of intelligent unit load, application and communication of data collisions occurring during treatment was introduced by a couple of specific examples. The subject area also offers several new tests. Further researches, the feasibility of the energy supply system, the system integrates with existing logistics infrastructure authorities will be analyzed. The goal is considered an intelligent preparation of load, the mathematical models and laboratory measurements of the intelligent systems.

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