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Radio Frequency Tagging within Life Science Facilities

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Executive Summary

Radio tagging technologies are gaining traction across a wide range of industries. Within life science facilities they offer opportunities to improve performance for product security, manufacturing, research and development, energy efficiency, safety and security, real estate management and resource planning. This paper explores some of the potential applications and benefits of using this technology as part of an overall intelligent building solution. It aims to promote further thought and discussion on their uses and future development.

Introduction

Radio Frequency Identification (RFID) and Real Time Location System (RTLS) technologies can be used in a wide range of applications to track and locate physical assets and people in real time. These technologies are already used in our day-to-day lives from simple bar code recognition systems and anti-shoplifting alarms through to patient tracking systems in hospitals.

Combining these systems with specialist application software allows companies to track and locate both people and physical assets within their facilities and provides real time and historical data about how their facilities are being used. This data can be used to deliver more streamlined operations, increased asset utilisation and improved productivity.

These technologies have traditionally been adopted within manufacturing and are increasingly being adopted in other industries such as healthcare, transportation and logistics. Adoption is being driven by the declining costs of implementation which is expanding application possibilities and improvements in the technology itself. The global RTLS solutions market is projected to reach over US$2 billion by 2018.

Within the life science and pharmaceutical arenas these technologies have potential applications across the following:

- Reduce drug counterfeiting and improve product security and consumer safety
- Support existing quality control procedures
- Improve manufacturing productivity
- Improve research and development productivity through asset and equipment utilisation and the management of consumables and hazardous materials. It can also be used for managing R&D space utilisation and to measure the collaboration between different groups or organisations
- Offer direct benefits for building occupants i.e. navigating around large estates, finding meeting rooms, monitoring lone working, personal distress alarm etc
- Improve building energy efficiency through integration with Building Management Systems (BMS) and Energy Monitoring & Targeting (EM&T) systems
- Enhance building security and safety by integrating with Security, Access Control, CCTV and Fire alarm systems
- Improve facility and real estate management
- Support business level resource and enterprise planning

Within life sciences the use of these technologies to improve manufacturing productivity and product security is not new. In 2004 the US Food and Drug Administration (FDA) published a report ‘Combating Counterfeit Drugs’ that recommended the use of radio frequency identification technology. Its potential uses may offer life science companies tangible operational and business benefits, that could provide additional return on their investment. Benefits can be maximised if these technologies are installed as part of an integrated building and energy management system and combined with business and enterprise level applications.

The examples highlighted within this whitepaper are not offered by a single manufacturer or system at present. Many require further development to put them effectively in practice. The goal of this paper is to explore some of the potentialapplications and benefits of using this technology within a life sciences facility as part of an overall intelligent building solution.

System Architecture

At a very high level these technologies can be divided in 2 basic groups, active and passive. Both systems include the following components:

1. Tags to hold and/or transit raw data

2. Radio network infrastructure (transceivers and/or sensors)

3. Location engine PC to interpret and filter the raw transmission data

4. Main system/report server to manage the overall application, display data to the end users and communicate data to other integrated systems

Active Systems

Active systems use intelligent active tags with on board batteries. They can use different radio frequencies such as Wi-Fi or Bluetooth (or others), which allows them to make use of existing IT infrastructure. A network survey is recommended beforehand to identify any vulnerability in the existing system and to highlight the need to install additional IT infrastructure if required.

The active system tags are more expensive than passive tags (up to 20x) but can support a number of additional features such as temperature and humidity monitoring, a personal distress alarm and two-way text communications (similar to a pager). The tags require re-charging and can have a battery life of several years depending upon the features they support and how frequently they are set-up to poll the network. For example, if tags have numerous features on a 1 second poll the tag battery will drain rapidly.

Passive Systems

Passive systems use less expensive tags. The tags obtain their power from a series of reader/energiser units that pulse radio waves at the tags. This requires a network of energiser units to be installed around the facility as part of the overall system infrastructure. The resolution of the overall system depends upon the number and location of these energiser units. There are also a range of semi-passive tags that have an on board battery to support the tag's microchip, but they communicate by drawing power from the energiser units.

The tags do not support a wide range of features but can remain operational for years with no intervention.

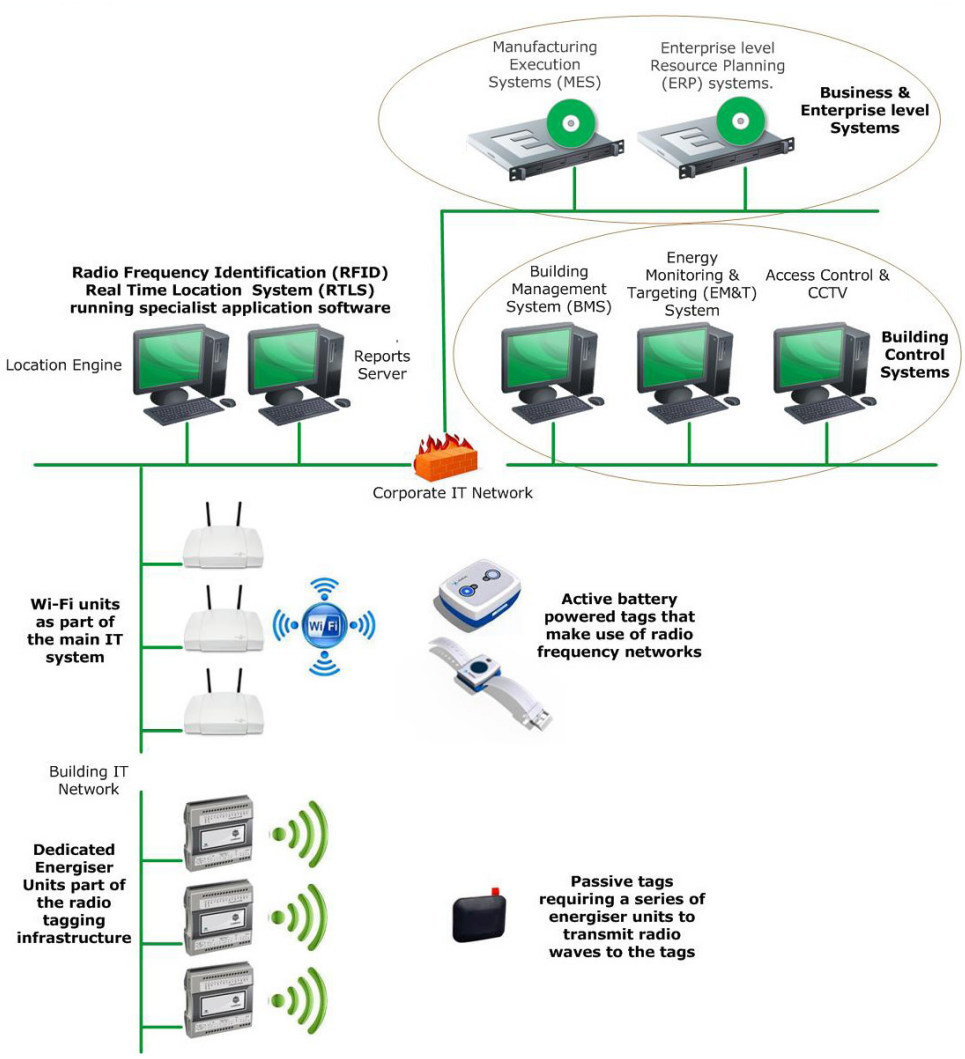
Integration

These systems can operate as standalone systems. It is also possible to deploy both active and passive systems within the same facility or building to meet specific requirements.

As detailed within this paper integrating RFID and RTLS with building control and monitoring systems can offer considerable operational benefits. Sharing this data at a high level with business and resource planning systems can provide further opportunities for longer term business and real estate planning.

System Architecture Schematic

Radio Tagging linked to Building Control and Enterprise Level Systems



Product Security

Product security and drug counterfeiting have implications for consumer safety but also for company finances and reputation. According to industry estimates between 2 per cent and 7 per cent of the world's pharmaceutical drug supplies are counterfeit, costing the drug industry approximately US $30 billion annually. In addition up to another US $40 billion of pharmaceutical drugs are lost or stolen annually.

RFID and RTLS can be used to support product serialisation to identify, track and trace the passage of prescription drugs from manufacturing through the entire supply chain. Not only can this be used to detect and deter counterfeiting it can also make is easier for companies to conduct drug recalls, manage inventory, and detect theft or diversion of shipments with obvious benefits to both pharmaceutical companies and patients alike.

Manufacturing Quality Control

RFID and RTLS can provide information to support existing quality control procedures by providing complete tracking and verification of manufacturing processes and finished pharmaceuticals. Product ID, time stamp, physical attributes, process machine reference, lot number etc. can all be encoded on a radio frequency identification tags and passed down the manufacturing process, onto warehousing and distribution and into the supply chain.

Manufacturing Productivity

These technologies have been used within a wide range of manufacturing industries to improve productivity. They can be applied to primary and secondary manufacturing within life sciences. Using these technologies to provide real time data to complement existing computerised systems around manufacturing, resource planning and maintenance management can be used to drive improvements in manufacturing efficiency and quality. Examples of their application include:

1. Manufacturing Information Management

Improve production execution and supply chain performance by providing real time, accurate and detailed information to existing Manufacturing Execution Systems (MES) or Enterprise level Resource Planning (ERP) systems.

2. Manufacturing Execution and Quality Control

Provide real time data to support manufacturing improvement programs such as Lean and Six-Sigma.

Improve quality control by tagging raw materials, work in progress and finished goods. Collect data on product ID, time stamp and lot number at each step of the manufacturing process and across the supply chain.

3. Tracking

Improve inventory tracking and visibility from raw materials through production, packaging, palletising, warehouse operations and final shipping.

4. Asset Management

Improve asset use by tracking mobile production assets. Provide visibility of their location and availability i.e. fork lift trucks, machines etc.

Research and Development Productivity

Research and development depends upon a wide range of factors and improving R&D productivity is an extremely complex problem to solve. These technologies can provide some tangible benefits and valuable information to support improved management of the R&D process and potentially reduce costs and improve results:

1. Space Utilisation

It is often very difficult to assess if adequate space is allocated to specific research activities. Radio tagging can quantify how spaces are being used by scientists and research groups. For a specific area it can monitor how many people are using the space (based on specific groups of people as noted below) and when they use it. Highlighting underutilised or over utilised space over a period of time allows fact based decisions to be made regarding the potential provision of additional R&D space or the redevelopment of existing spaces.

The quantitative analysis of occupancy will be useful across almost all R&D activities, but will be particularity useful in multi-use or multi-let research spaces where the buildings are being used by a range of different scientists or scientific groups.

NOTE: When monitoring people movement it is common to assign tags to groups of people rather than specific individuals. In this way it is not possible to track the movement of a specific individual and their personal privacy is not compromised. Companies can assign groups according to their specific business or organisational structure i.e. oncologists, neurologists, facility staff, security staff, support staff, visitors etc.

2. Measurement of Collaboration

Effective collaboration between different groups within an organisation is often critical to its success. This is particularly important within the R&D arena. Within life sciences there is also a growing trend for different organisations or different companies to collaborate across a single R&D project. These technologies allow the interaction between groups and organisations within the same building to be monitored, measured and quantified. Highlighting a potential lack of collaboration should allow steps to be taken early to address any potential problems or issues. Similarly highlighting spaces that appear to promote collaboration should give designer and managers a better understanding of how to make collaboration work.

3. Asset Management

R&D equipment is often expensive and in high demand by many different scientists. Radio tagging allows users to track mobile R&D assets and provide visibility of their location and availability (i.e. bench top equipment such as centrifuges, incubators, balances etc). This allows expensive equipment to be shared more efficiently or redeployed between different departments reducing both capital expenditure and ongoing operational costs (i.e. equipment re-calibration, maintenance etc). It can also make equipment easier to locate when needed or when due for maintenance.

4. Consumables Management

R&D consumables can be expensive and it is common for individual groups to hold and manage their own stocks. Radio tagging can help manage consumable inventory and track visibility and availability in real time. Not only will this allow overall consumption to be monitored and managed but where different departments use identical consumables it will allow these to be efficiently shared minimising both stock holdings and reducing waste due to potential expiry of use by dates.

It can also be used to support existing safety procedures with regard to the handling and storage of hazardous consumables. These consumables could be identified and their location tracked in real time highlighting if hazardous chemicals are not in a safe location (i.e. an appropriate laboratory or chemical store). Some active tags can also support local temperature and humidity monitoring for any environmentally sensitive consumables.

Building Energy Efficiency

Life science facilities are highly serviced buildings with significant energy and utility consumption. Improvements in building energy efficiency are not only important from a sustainability perspective, but can also generate significant financial savings to help drive top line value.

Most life science companies already focus on energy efficiency. They often use a Building Management System (BMS) to control and monitor the heating, ventilation and air conditioning (HVAC) within their facilities and an Energy Monitoring & Targeting System (EM&T) to monitor and benchmark energy and utility consumption.

Integrating radio tagging technologies with BMS and EM&T systems opens up a myriad of possibilities to both optimise HVAC systems and cross reference energy consumption against actual occupancy. It is widely accepted that in order to improve building energy efficiency one of the first steps is to measure and monitor energy consumption. Energy consumption profiles demonstrate when and how much energy is being consumed, but not why. Radio tagging technologies can track building occupants in real time and provide invaluable quantitative data about how the building is actually being used. Cross referencing this building use data with data from BMS and EM&T systems could provide a missing piece of the jigsaw.

Some examples of how this technology could be applied to building energy efficiency include:

1. HVAC Setback

HVAC systems could be automatically switched off or changed to a setback mode of operation when spaces are unoccupied (i.e. reduced air change rate or relaxed temperature and humidity controls).

For common multi-use areas like hot desk areas this could be extended to effectively mothball entire sections of a building and re-direct occupants to use other areas of the building. As the building begins to fill up HVAC systems serving mothballed areas could be re-started and the mothballed area opened up for normal use.

NOTE: In terms of building control systems PIR's are conventionally used to monitor occupancy status, but these cannot monitor how many people are occupying the space.

2. HVAC Performance Limitation

Rather than simply linking HVAC setback to occupied or unoccupied status the HVAC performance could be linked to occupancy density. The HVAC system output could be limited to a pre-set maximum during periods of low occupancy density i.e. prevent air handling units operating at 100% duty if the associated areas are only at 20% occupancy. This control could be used to augment exiting CO_2 based control routines.

3. Occupancy Type

HVAC systems that are linked to occupancy could be programmed to only react to the right type of occupant. For example office fan coil units would only turn on when office workers are present and would not react to other potential transient occupants such as security staff or cleaners.

4. HVAC Utilisation

By monitoring both occupancy patterns and the operation of the individual HVAC systems it is possible to highlight potential problems such as:

- Overpopulated Areas - Alarms could be raised when areas are regularly populated above their original design intent. Operating HVAC systems outside of their normal design performance envelope is likely to cause them to operate inefficiently. Raising alarms when this occurs allows building managers to take appropriate actions to address the issues.
- Underused Areas - Alarms could be raised when areas are consistently sparsely populated. HVAC systems will still need to run to serve these areas but maybe operating inefficiently at a very low load and may be providing minimal operational benefit due to the ow occupancy use.

5. Open Loop Control Algorithms

Radio tagging could permit the use of open loop based control algorithms based on occupancy density. These would need to be reviewed on an case by case basis but could be used to replace or supplement conventional closed loop control routines which are typically based on environmental feedback. For example:

- The ventilation rate serving a lecture theatre/auditorium could be controlled using a combination of the actual measured occupancy density and CO2 rather than just detected CO2, temperature or levels of volatile organic compounds. Depending upon the configuration of the HVAC system it may be possible to control the ventilation rate to specific densely populated pockets, for example a lecture theatre may only be a quarter full, but it is likely that several areas within the theatre are fully populated.
- The fresh air supply for office areas without full air quality controls could be controlled on actual density based on a minimum airflow per person, rather than a pre-determined arbitrary minimum setting on the AHU dampers. This would allow the volume of fresh air to be minimised during period of low occupancy density.
- Pharmaceutical clean room ventilation is a potential area for future study. Due to the high air change rates recommended within clean rooms the associated HVAC systems consume significant amount of energy. In many clean room applications people are the main source of particulates and their activity levels affect the amount of particulate generation. Applications could include the optimisation of clean room ventilation rates according to the actual measured occupancy density and activity. Ventilation rates could be reduced with the rooms at rest, and only increased during active use. Considering the criticality of most clean room applications this would require extensive study, testing and validation, but could offer considerable energy savings.

6. Time Schedules

Radio tagging could be used to augment or replace passive infrared (PIR) occupancy detection to start and stop HVAC plant items once a minimum occupancy density has been detected within a space. By measuring actual occupancy patterns over an extended period of time, pre-set time schedules can be adjusted to better match HVAC operation to actual building use.

7. Sub Metering

Within multi-use or multi-tenanted facilities it may be possible to link actual observed occupancy patterns with sub metering data from EM&T systems by cross referencing the energy use of a specific department to its measured occupancy levels.

For multi tenanted facilities it may be possible to develop EM&T systems that could bill individual tenants based on their actual use of the facility, charging individual clients for actual measured laboratory use within a multi let bio-hub facility.

8. Benchmarking

Occupancy densities and patterns could be compared against energy use profiles and used to provide additional benchmarking statistics like energy use per person.

The examples highlighted above relate to applications where the performance of the HVAC systems is largely based upon occupancy levels. Within life science facilities there are other considerations such as safety, product quality, process loads etc. that if applicable to a specific HVAC application will always take precedence.

Safety and Security

Personal and product safety and security are paramount within life science facilities. RFID and RTLS can be used to prevent drug counterfeiting and to help manage hazardous consumables and raw materials. They can also be used to enhance both personal and building safety and security:

1. Personal Safety

In terms of personal safety the technology can be used to:

- Detect lone working and highlight lone working in a potentially hazardous area.
- Detect a potential fall and highlight the location by detecting if a tag is at floor level and/or there has been no movement for an extended period of time.
- Help rapidly locate the nearest qualified first aider to an incident.
- The tags can include a distress alarm. This alarm can be sent to security and show the location of the incident.

2. Equipment Security

Radio tagging can be used to raise an alarm if a tagged item of equipment is removed from a designated area like a specific laboratory or building. The tags can also include inbuilt technology to alarm if they are removed from an item of equipment.

3. Access Control, CCTV & Fire Alarm

Integrating these RFID and RTLS with building access control, CCTV and fire alarm systems opens up a range of possibilities to improve system functionality:

- Controlling access to areas of the building by linking specific groups of tags to door access controls.
- Monitoring movement throughout the building. The monitoring of individual groups like visitors could be undertaken throughout the building rather than just at swipe card points.
- Automatic CCTV pan, track and record could be incorporated for specific events. This could be automatically activated if a personal distress alarm is triggered, a potential fall is detected or a tagged item of equipment is removed from an area etc.
- They could provide data to support fire or emergency evacuation procedures by highlighting if people remain within the building following an alarm or evacuation. NOTE: Radio tagging should not be used as the primary record for any life safety systems. Radio networks can fail and occupant tags can be taken off.

User Benefits

With the use of mobile devices radio tagging can include the deployment of applications that simplify and streamline people's day to day activity at work. These include:

- Local adjustment of comfort conditions i.e. temperature, light levels etc.
- Finding mobile equipment. As well as being used to track and locate equipment the equipment tags themselves can be set to flash or buzz to allow users to easily find items of equipment.
- View building layouts and plans to help people navigate around large buildings or estates. They can include a 'find me' function to dynamically display a person's office on the displayed building floor plan.
- Find a meeting room, view real time availability and reserve it.
- Dynamically display building occupancy levels to allow users to easily find the closest available free hot desk area.
- Contribute directly to personal safety including lone working detection, fall detection and personal distress alarms.
- These applications can also be used to display general company information like company news, the restaurant menu for that day, provide a method to report a maintenance issue to the facilities team.

Some of these features will rely on the integration with other building systems like meeting room booking systems.

Facilities and Real Estate Management

In facilities and real estate management it is often difficult to ensure that you have the right amount of necessary space. This is particularly difficult within a life science arena where there is a constant need for change, to address business needs or R&D requirements. Plans are often based on business projections, anticipated demand or gut instinct based on previous experience. These technologies can be used to provide qualitative and quantitative data to support both dynamic space planning and to provide a record of historical use for long term planning and overall real estate development.

Quantifying exactly how and when spaces are being used allows managers to make rapid fact based decisions. It allows them to optimise their dynamic space planning by adapting spaces to meet actual needs, making the best use of the available space and saving costs.

Historical data gives a longer term view of building use. This data can be analysed by internal facility teams or external specialist consultants. It can be used to plan redevelopment, refurbishment, and new build activities or conversely highlight the need to mothball or shutdown assets. This long term data can also demonstrate how effective a building has been at meeting the needs of its occupants i.e. how effective have collaboration spaces been? Where were the most popular places for people to work? This information can be fed back into future design plans to ensure that lessons are learnt and future facilities can be more productive and pleasant places to work.

Resource and Enterprise Level Planning

Radio tagging can have applications at the business level for resource and enterprise level planning. They can be used to provide real time, quantitative data about how the processes within a facility are operating and how the people within the facility are actually using it. Presenting this information at business or enterprise level will provide facility owners, managers and developers with valuable information to both optimise day-to-day activities and reliably plan for the future.

In both the short term and long term it should provide them with data to help them to maximise the efficiency of their facilities. The data from this technology has implications across the following:

1. Manufacturing Productivity

Support high level Manufacturing Execution Systems (MES) and improvement programs such as Lean and Six-Sigma.

2. Research Productivity

Quantify space utilisation, measure collaboration between different R&D groups, and manage physical assets and consumables.

3. Building Control & Energy Efficiency

Optimise HVAC systems and benchmark energy consumption against actual occupancy in real time.

4. Safety & Security

Improve personal safety, equipment security and integrate with access control and CCTV systems.

5. Real Estate Management

Dynamically mange spaces to rapidly adapt to actual business needs. Review historical data to better plan for the future.

Business Justification and Return on Investment

Return on investment is difficult to quantify for life science facilities across the board as it depends largely upon the particular application or activities being undertaken within the facility. The cost of ownership has been a barrier for large scale adoption throughout the industry however the declining price of both the hardware and software combined with improvements in the technology and expanding application possibilities builds a stronger business case for investment. For example the expansion of Wi-Fi mesh networks throughout life science facilities and the potential use of smartphones and smart watches as enhanced active tags both illustrate of how elements of this technology are already present in facilities today.

Implementing these technologies within the concept design for new facilities and integrating them with traditional building control and monitoring systems and with business resource and enterprise level planning systems can greatly increase their business benefit and reduce financial paybacks. It is important to remember that any investment decisions should take into account both the capital costs and the ongoing operational costs to ensure that the data from these systems is managed effectively.

Conclusion

Radio Frequency Identification (RFID) and Real Time Location System (RTLS) both have a strong use case within the life science industry. The decision to invest in these systems can be complex but improvements in the technology itself, expanding application possibilities and the general declining costs, strengthen the business case for investment.

Although they can be provided as local independent systems, the potential return on investment can be maximised by integrating them with more traditional building control and monitoring systems and onto high level business and resource planning systems. This could be particularly beneficial if they are included as part of the base building design and designed, installed and commissioned as part of an overall intelligent building solution.

Fundamentally they provide facts and data about processes and people movement within the facilities. They can track materials within a process from start to finish and track occupants around a building in real time. They provide a true quantitative understanding of how a building operates and how it is being used by its occupants.

In a life sciences environment RFID and RLTS can provide tangible and immediate operational and financial benefits around product security, manufacturing quality control, manufacturing productivity, R&D productivity, building energy efficiency, building and personal safety and security, user benefits and space planning. The information from these systems can be viewed dynamically or historically to build up a long term picture of actual performance. Historical data can be used to improve existing facilities but also has the potential to be fed back into the building design and development process to improve future facilities. It has the potential to allow us to improve the way we interact with the building we work in making them a more productive and more pleasant place to be.

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