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An Introduction to RuBee Technology

An Oracle & Visible Assets Inc.

White Paper

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Executive Overview

The outlook of RFID (Radio Frequency Identification) technology has failed to deliver and meet the expectations demanded by Enterprises today. RFID has been largely unsuccessful to consistently track where all of your assets are in real-time with 100% accuracy. Some of these issues are based upon physics (e.g. radio waves), which are affected by just about everything surrounding us. Many environmental factors influence RFID performance, such as: steel, water, people and electrical noise sources are just a few examples. However, after 20 years of research & development investment, a new technology called RuBee has been introduced to the market. RuBee can read through steel, water and overcome harsh environments which RFID cannot even attempt to address. New RuBee enabled Visibility systems will forever alter the manner in which information is collected, integrated, accessed and reported. All too often, enterprises rely on manual processes and a significant amount of time and effort to describe, verify and document information about the status and quantity of their assets on-hand. The application and deployment of RuBee Technology virtually eliminates the need for endless and redundant manual documentation we observe today.

Introduction

Visible Assets, Inc. (VISIBLE™) VISIBLE sells asset visibility networks based on an IEEE worldwide standard wireless technology known as RuBee (IEEE 1902.1). RuBee provides low cost, long-life, low power, wireless, active asset and personnel tags that work in industrial environments, in and around metal, water, and people. These visibility networks use Dot-Tag™ systems based upon Oracle that “virtualizes” the RuBee enabled asset network of tags into a real-time visibility database and web enabled visibility application. The Oracle/Visible 20/20™ System quickly creates any visibility application on top of the Dot-Tag/RuBee network. The Visible Asset 20/20 and Dot-Tag systems are both Oracle embedded database products. Visible and Oracle sell 20/20 Dot-Tag RuBee visibility networks through industry-focused partners in a variety of markets including healthcare, high security government, high security commercial, agriculture, aircraft parts, aerospace, mission critical tools, weapons, and construction. RuBee is a physics breakthrough based on a 20 year development effort and is protected by 21 issued US and foreign patents and approximately 60 additional pending and foreign patents owned by Visible.

What is RuBee?

RuBee is a long wavelength (LW), inductive, active protocol with a 10-15 year battery life and a range of 1 to 100 feet with optional sensors. RuBee tags overcome many of the technological problems seen with RFID near steel and water, and is field proven in harsh environments.

RuBee is an IEEE issued standard (IEEE 1902.1), approved as of January 2009. RuBee is the only wireless technology to be approved by the US Department of Energy (DoE) for use in high security, top-secret areas where RFID, WiFi, Bluetooth and Zigbee have all been banned. In July 2006, the FDA classified 1902.1 as a Non-Significant Risk (NSR) Class 1 device in medical visibility applications. In April 2007, the FDA issued a warning that HF and UHF RFID may have an untoward effect on implantable devices. In May 2007, a peer-reviewed study was published by the Mayo Clinic showing that RuBee has no effect on pacemakers or ICD's (Implantable Cardioverter Defibrillator). A second Mayo study has shown RuBee has no EMI (Electro Magnetic Interference) or EMC (Electro Magnetic Compatibility) in the operating room (Mayo EMI Study). The company has started independent laboratory tests and expects its RuBee tags to meet the Intrinsically Safe ANSI 913-88 standard in a Zone 0 or Zone 1 explosive atmosphere as well as the Dept. of Defense HERO (Hazards of Electro Magnetic Radiation to Ordinance) standards.

The IEEE 1902.1 Protocol Details

The 1902.1 "physical layer" workgroup is composed of 17 corporate members (Epson, Motorola, Microsoft, GE, GM, LG Electronics, Bearing Point, RFTechnologies and many smaller companies). The Workgroup was formed in late 2006. The final specification was issued as an IEEE standard in March 2009. The standard includes such things as packet encoding and addressing specifications. The protocol has already been in commercial use by several companies, in asset visibility systems and networks. However, IEEE 1902.1 will be used in many sensor network applications, requiring this physical layer standard in order to establish interoperability between manufacturers. A second standard has been drafted (1902.2) for higher-level data functions required in Visibility networks. Visibility networks provide the real-time status, pedigree and location of personnel, weapons, hazardous materials, medical supplies or other high-value assets within a local network. The second standard will address the data-link layers based on existing uses of the RuBee protocol. The 1902.1 standard, which will be essential for the widespread use of RuBee in visibility

applications, supports interoperability of RuBee tags, RuBee chips, RuBee network routers and other RuBee equipment at the data-link layer.

RuBee Tag Details

A typical RuBee Wireless Tag has a 4 bit CPU, 1 KB sRam, a crystal, and lithium battery with an expected life of 10-15 years. RuBee is bidirectional, on-demand, and peer-to-peer. It can operate at other frequencies (e.g. 450 kHz) but 131 kHz is optimal. RuBee tags can have sensors (temperatures, humidity, jog), displays and have a 4-bit microprocessor with static memory. The RuBee protocol uses an addressing structuring similar to IP Addressing (Internet Protocol Address). A tag may hold data in its own memory in addition to having data stored on a server. Tags may have as much as 5 KB of memory. RuBee functions successfully in harsh environments, with networks of many thousands of tags, and has a range of 1 to 100ft. By 'harsh environment' we mean situations in which one or both ends of the communication are near steel, water, or people. RuBee wireless tags function in environments where RF-based tags such as RFID have problems. RuBee networks are in use in many visibility applications, including managing inventories of weapons, hazardous materials, and high-value assets at highly secure US Government facilities.

How RuBee Works

IEEE 1902.1 RuBee uses magnetic waves. This type of communication is also often called inductive communication. James Clerk Maxwell presented his now famous set of equations (Maxwell's Equations) to the Royal Society in 1864. These equations describe what happens when an electron travels along a conductive wire. Two fields are created, the Electric Field, labeled **E**, and the Magnetic Field, labeled **H**. Virtually all of the energy radiated by a RuBee base station or a RuBee radio tag is contained in the magnetic field (**H**), not the electric (**E**) field. Finally, RuBee is a packet based protocol in which only one end of the communication at a time generates fields, that is, a RuBee tag is a radiating transceiver.

Environmental Factors

RF (Radio Frequency) is not always predictable because the active environment (people, steel shelves, floors, cabinets, doors) are all part of the same tuned circuit, and change with time. For example, a cell phone call to a phone in a building is modified by steel in the building. Moving the phone near a window or pointing the antenna in a particular direction may improve reception. Radio waves are affected by just about everything around us. Many environmental factors influence performance. The more significant ones include steel and water, but people and electrical noise sources are also high on the list. In contrast, magnetic waves can pass through almost anything, even rock. That same rock blocks RF after only a few feet.

RuBee is 99.99% magnetic waves! Therefore it is not affected at all by people or animals, mud or water. Steel can alter performance, but steel can actually enhance a magnetic signal. Long Wavelength magnetic transmissions (below 1 MHz) are not blocked or reflected by steel so nulls do not occur.

RuBee has good “Feng Shui” in industrial environments because most steel items resonate well at the RuBee frequency of 131 kHz. As the frequency goes up over 1 MHz fewer steel items resonate. At a frequency of 10 MHz for example, nothing large made of steel can be tuned to resonance.

How big can a RuBee loop antenna be? As the antennas get larger and larger noise becomes the gatekeeper. A 100 ft (30 m) diameter loop can detect lightning storms hundreds of miles away. The biggest source of noise is deep space kilometric noise. While it is possible build a second antenna and conduct differential subtraction, a 10,000 sq ft limit of a RuBee network is adequate for most practical visibility applications.

RuBee Major Selling Points (RuBee is not RFID!)

RuBee is an on demand peer – to - peer protocol that works like WiFi, except it uses magnetic waves not radio waves. The use of magnetic energy brings about a number of advantages:

- **100% Reliability in Industrial Environments:** RuBee works in and around metal, water, and people. RFID does not, because RF signals are reflected by metal, and absorbed by

water. Steel can actually enhance the RuBee signal, and extend the range. RuBee is minimally affected by noise sources in the environment.

- *Benefit: RuBee addresses industrial environments (metal/water/people), where RFID does not work reliably. RuBee is designed for 100% reliability in the most demanding industries: Defense, Healthcare, Oil & Gas, Mining, etc.*
- **Volumetric Not Directional:** RuBee antennas generate a controlled, 3-dimensional volumetric field. In contrast, RFID antennas generate a directional, “angled cone” reading area, similar to a flashlight beam.

Benefit: User does not have to do anything in particular to make the system work. A RuBee antenna built into a weapons rack will automatically read all the weapons on the rack. An RFID reader on a weapons rack will only work if you deliberately point the tag at the reader, or the reader at the tag.

- **No Change In Process (CIP):** With RuBee, users do not have to do anything different in order to manage inventory on shelves or in vehicle rooms. RuBee is Visibility with no Change in Process (CIP). People do just what they did before and the system automatically manages the flow of personnel and high-value assets. This is only possible with RuBee, because only RuBee works through metal, water & people and generates 3-dimensional reading volumes.

Benefit: With RuBee, the customer achieves a big ROI because there is no “Change in Process” required. If you require a Change in Process, it will cost an enterprise more to invest in training and compliance, but you will not achieve a goal of 100% reliability! RFID will always require a “Change in Process” in industrial environments (due to metal, water, or people). As a result, in those environments RFID offers no incremental savings over barcodes, although it will require greater expense.

- **Controllable Range:** RuBee signals have a controllable range from less than 1 foot up to 100 feet. In contrast, RF signals have a range that cannot be controlled. RF-based systems such as RFID may be designed to work in a specified range but in practice it is not possible to ensure that they work (or don't work) at a greater range. This aspect of RF presents two problems: inability to accurately report where a tag is, and security risks that are detailed below.

Benefit: RuBee networks operate in controlled, predefined ranges. When a RuBee appliance such as a SmartShelf reports a tag read, that is because the tag was found inside that known and pre-defined volumetric range. The RF signals in RFID operate in ranges that are not well defined. As a result, RFID systems are more suited to “tracking” key points than to providing the real-time “visibility” which you can achieve from RuBee.

- **Security:** Because of the controllable range of the signals, RuBee is the only wireless technology that virtually eliminates tempest, target, and eavesdropping risks. The signals cannot be detected beyond the specified range of the system, which can be a few inches or up to 100 feet. As a result, you cannot improperly use a RuBee system to secretly send information out of a secure facility (tempest risk), others can't listen in on communications from outside the facility (eavesdropping risk), and the enemy cannot use the RuBee tag you're carrying to find you on the battlefield (target risk). The US DoD (Department of Defense) issued a Shot Counting RFP for a new Spec Forces Assault Rifle ("SCAR"). RuBee is the only wireless technology approved for that RFP, due to target risk. An additional DoD certification pending for RuBee is HERO (explosive risk around weapons and munitions).

Additionally, RuBee tags have a battery, a crystal and sRAM memory. This provides the capability for strong encryption with nearly unbreakable one-time keys, or totally unbreakable one-time pads. RuBee is in use today in many high security applications for these reasons.

Benefit: RuBee is the only wireless technology suitable for deployment at secure government locations and on the battlefield. RuBee tags have passed stringent security tests, and are in use within some of the most secure sites around the world where all other wireless technologies (RFID, Wi-Fi, Bluetooth, and ZigBee) are banned. RuBee Security Plans have been approved for use in the highest security areas of the US Government.

- **Smart RuBee tags have** a programmable microprocessor, with crystal clock for date and time, 10+ years battery life with a thin coin-sized Lithium-Ion battery, sensors, and sRAM memory.

Benefit: Since data is stored in the tag, IT costs are reduced. This means that with a handheld reader one can simply read a RuBee tag and learn about the asset (e.g. manufacturing data, expiry date, lot number, etc.) without having to go to an IT system to look it up. In addition, the distance between the reader and the asset is not critical. RuBee

can also write to a tag at the same range as it can read it. RFID, on the other hand, uses EEPROM memory, and writing to the tag is awkward. (In the case of RFID, range is limited; more power is required and write times are long.)

- **Human/ Environmental Safety:**

- o RuBee has no known human safety issues and has no known risk to ICD or pacemaker wearers. RuBee is many millions of times below OSHA limits for safe human RF exposure.
- o Because of its low power, RuBee has no known intrinsic safety, EMI or EMC issues with munitions, weapons or medical grade equipment that meets IEC 60601-1.
- o RuBee has been reviewed by the FDA and is classified as a Non-Significant-Risk (NSR) Class 1 device, for use in Operating Rooms. In fact, RuBee produces less power and lower field strengths than the metal detectors in airports and the anti-theft detectors in retail stores operating at similar frequencies — by a factor of about 10 to 100.

Benefit: No known human safety risks. RuBee is suitable for use in hazardous, explosive environments and is safe for use in hospitals, including operating rooms.

- **Pressure & Environment Stress Tests:** Specialized RuBee tags have passed many extreme tests: 20,000 .40cal round endurance testing; MIL-STD 810G – immersed in Jet A fuel and 13 other harsh solvents, placed under water for 24 hours at 66 feet, sprayed with salt water for 24 hours, at -50C and 80C for hours – and the tags continue to work! RuBee tags have passed EMI testing for mission critical phone equipment (NEBS).

Benefit: Stress tests prove the tag will continue to operate and send/receive data under the most extreme conditions. Minimum risk and cost to identify locate and replace tags. There is significant manpower savings.

- **Licensing:** The RuBee protocol is an international wireless standard, IEEE 1902.1 unanimously passed by corporate balloting at the Institute of Electrical and Electronics Engineers (IEEE). IEEE 1902.1, the RuBee protocol and RuBee applications are all available for licensing.

Benefit: Worldwide standard issued by the premier electronics standards organization, the IEEE.

- **Industry Solutions:** RuBee Visibility Systems are used in Weapons, Oil & Gas, Mission Critical Tools, Security Systems, as well as many other asset visibility applications.

Benefit: Numerous RFID project have been shelved to date, due to requirement and technology limitations. RuBee opens up the possibility to address past RFID project failures, while creating new solutions for numerous industries, due to the change in physics.

- **Disadvantages:** Speed and packet size. The RuBee protocol is limited to 1,200 baud in existing applications. It is expected that IEEE 1902.1 will also specify 1,200 baud. The protocol could go to 9,600 baud with some loss of range and reduced “Feng Shui.” However, most visibility applications work well at 1,200 baud. Packet size is limited tens to hundreds of bytes. RuBee's design forgoes high bandwidth, high speed communication because most visibility applications do not require them.

The Oracle Dot-Tag Visibility Engine

The Dot-Tag visibility engine is based on Oracle 11g. As a result, RuBee's wireless technology backbone is now supported by Oracle's Core Technology: Complete, Integrated, Based on Open Standards, Scalable, High Availability and End to End Security. RuBee in effect turns every asset into a tiny website, and creates a real-time “Internet of Things”. The Oracle Dot-Tag Server provides the foundation and infrastructure for enhanced asset integrity, accurate real-time product pedigree, physical inventory, active inventory management, 21 CFR Part 11, and Sarbanes Oxley audit logs. A typical Dot-Tag network includes the following: RuBee wireless tags with optional sensors, RuBee antennas and appliances, RuBee routers, a centralized visibility engine (Oracle Dot-Tag server), database tools, VPN, TCP/IP drivers, protocol tools, network diagnostic tools, network and audit management tools.

The Oracle Asset Visibility Integration Toolkit

The “Oracle Asset Visibility Integration Toolkit” was developed by OARDC (Oracle Asia Pacific Research & Development) to integrate to Oracle Fusion Middleware and extend the Oracle eBusiness Suite application as well as other third party commercial packaged applications. This toolkit is designed to collect real-time data from RuBee devices and the Oracle Dot-Tag Server, manage and direct the data traffic through a routing engine (e.g. BPEL Workflow), and finally transform the visibility data into something that packaged applications can consume. The integration is based upon open standard APIs such as Web Services and PL/SQL.

The toolkit acts as a bridge between the commercial packaged application such as Oracle E-Business Suite, PeopleSoft Enterprise, Siebel, and SAP and visibility technologies to provide a unique value proposition for enterprises to enjoy the benefits of both technologies without incurring a major investment in the development effort.

Conclusion

RuBee is not RFID! RuBee has been tested and proven in many different harsh environments today. RuBee also received the Frost and Sullivan award for technological innovation in 2007, as well has been approved for meeting the IEEE standard P1902.1. RuBee has no known health or safety risks. RuBee's security has been approved at 9 of 12 Department of Energy sites for use in the highest security areas (where RFID, Zigbee and WIFI have been banned). Based upon the above facts, and leveraging Oracle's core applications and technology products, solutions can be configured for Weapons Healthcheck, Hazardous Materials, Oil & Gas, Mining, Airline Maintenance & Tools and tracking highly expensive and mobile assets in the Healthcare Industry. Only Oracle and Visible Assets Inc. have the potential capabilities to address your “visibility” problems today.



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