IT Tralee Masters by Research Programme Details

Title of Project: Secure traceable transportation of pathology specimens using the Internet of Things

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Brief Biography of Principle Supervisor:

Andrew is an academic staff member at the Institute of Technology Tralee (ITT), lecturing in numerous computing related disciplines. He has also been heavily involved in the research activities at the institute and is currently principle investigator on an Innovation Partnership project working on RFID and sensor systems. Previously Andrew was strand leader at the IMaR technology Gateway where he has completed numerous applied research projects, working directly with companies both locally and nationally. Much of this research involves applying machine learning and analysis techniques to a myriad of different domains such as. RFID systems, public wireless networks, sensor network energy monitoring systems and student data from e-learning systems. In 2008 he was the event coordinator for three high profile events at the ITT, two of which had Nobel Prize winners as the key note speakers Sir Clive Granger and Prof Andrew Fire.

Recent Research Publications:

Shields A, Doody P, Scully T. 2017. Application of multiple change point detection methods to large urban telecommunication networks., 28th Irish Signals and Systems Conference 2017. IEEE, Killarney, Co Kerry.

Nukala R, Panduru K, Shields A, Riordan D, Doody P, Walsh J. 2016. Internet of Things: A review from 'Farm to Fork, 27th Irish Signals and Systems Conference 2016. IEEE, Ulster University, Derry.

Mc Gough R, Shields A. 2016. A study of technology adoption and usage behaviour for students in Higher Education in Institutes of Technology, Annual Irish Educational Technology Conference EdTech 2016, Law Society of Ireland Education Building, Dublin, Ireland (http://ilta.ie/edtech/edtech-2016/)

Shields A, Mc Carthy U, Riordan D, Doody P, Walsh J, Uysal I. 2015. Radio Frequency Identification (RFID), Wiley Encyclopaedia of Electrical and Electronics Engineering, John Wiley & Sons, Inc. (http://dx.doi.org/10.1002/047134608X.W8155)

Nukala R, Shields A, McCarthy U & Ward S. 2015. An IoT based approach towards Global Food Safety and Security. The 14th IT&T Conference, National College of Ireland, Dublin, Ireland, 10-17, ISSN 1649 1246 (http://ittconference.ie/uploads/conference/2015/ITT_Conference_Proceedings_2015.pdf)
Kossakowska J, Shields A, Sheehy R, Doody P. 2015. Intelligent Profiling of Blood Donors in Ireland. Conference Evolve Biomed 2015, Dublin Ireland 2015 (http://www.evolvebiomed2015.com)

Shields A. 2014, Using RFID to Establish a Secure Blood Supply Chain, RFID Journal Live 2014, 11th International Conference, London, England
Shields A, Dwyer B, Crowley B. 2014. Using Mobile Phones as Social Monitors of Engagement for the SME. Proceedings of the 2014 ICSB 2014 World Conference on Entrepreneurship, ICSB, Dublin Ireland

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Doody P, Shields A. 2012. Mining network relationships in the internet of things. Proceedings of the 2012 international workshop on Self-aware internet of things (Self-IoT '12). ACM, New York, NY, USA, 7-12. DOI=10.1145/2378023.2378026 (http://doi.acm.org/10.1145/2378023.2378026)

Doody P, Shields A, 2011. Relationship Classification of Object to Object communications in the Internet of Things using
Reality Mining, RFID in Europe, RACE network, Prague, Czech Republic (http://www.race-networkrfid.org)

Shields A, Datta S, 2008. Can We Apply Principles From Social Networking To Healthcare Informatics For Intelligent Data Analytics? MIT Libraries DSpace (http://hdl.handle.net/1721.1/43944)

Shields A, Butcher D, 2007. A Local and Remote RFID Learning Environment. 8th Annual Irish Educational Technology Conference EdTech 2007, DCU, Dublin, Ireland (http://www.ilta.net)

Research Project Abstract

Pathology systems are beginning to utilise modern identification solutions to address the issues of specimen traceability. However, several issues still remain to be solved. The current methodology being used is to adapt existing track and trace RFID systems. These existing systems generally operate internally within a single pathology laboratory or Hospital setting. These are insufficient to solve the issues of security and logistics outside of a lab setting and are totally inadequate when transporting samples to other jurisdictions. This causes issues with sample integrity, security and chain of custody, and may in fact limit the ability of a laboratory to tender for toxicology contracts that require full chain of custody.

This project aims to investigate uniting several technologies and apply them to pathology logistics. Current pathology systems require the labelling of a specimen then the transportation of that specimen to a laboratory for analysis. Several technologies can be used to facilitate traceability, Internet of Things (IoT) being the main enabling technology coupled with Smart objects and Future Internet. These technologies are currently state of the art but have not been utilised in the pathology area. Another important factor is the integration to existing systems using middleware that conforms to existing standards, and ensures security and privacy of data. One benefit of using IoT technologies would be to monitor more than just the ID of the specimen for example the temperature based quality assessment of a specimen may be monitored throughout its entire cycle, from donor to patient - reducing waste and associated costs.

The contributions of the project will be in the combination of recent technological advances from Internet of Things, RFID, Smart Interconnected Objects, Cloud Computing and the Future Internet to achieve monitoring of each specimen at every touch point in the pathology supply chai. Such a system would enhance patient safety, improve turnaround times for patient results, minimise errors, guarantee confidentiality of patient data and ensure specimen integrity and specimen quality.

Research Context (Technical Merit & Impact)

Problem to be solved

Despite a significant decrease in analytical errors in clinical laboratories in the past few decades, there is an increasing awareness of errors in the pre-and post-analytical areas in the total testing process (TTP). In a recent study [i], errors in the pre-analytical phase (defined as the time the test is ordered by the physician until the sample is ready for analysis) can account for up 93% of the errors encountered in TTP. A review [ii] of multiple studies in 2002 showed similarly high levels of errors.

The suitability and integrity of samples arriving at the laboratory is influenced by a number of factors. Patient status and preparation can contribute, for example inadequate patient preparation (i.e. fasting or not fasting, medications, presence of physical agents (drips, infusions etc) and infection status. Poor phlebotomy procedures will also contribute to unsuitable specimens being received at the laboratory. However, the majority of errors in pre-analytical processing occur because of misidentification
Identification errors have the potential to cause serious patient harm. Wrong-patient cancer resections and fatal transfusion reactions have been reported.[iii, iv, v] A project conducted at the University of California, Los Angeles (UCLA) clinical Laboratories in 2002 studying three types of errors, unlabelled specimens, specimen/requisition mismatch and mislabelled specimens showed that these errors accounted for 11.9% of all specimen errors during the study periodvi. In a busy pathology laboratory, correcting and rectifying these errors decreases overall efficiency and productivity thus leading to increased costs.

A study [vii] of pre-analytical processes, showed that on average it takes one minute to process a sample request for analysis. Reported error rates for pre-analytical errors vary between 0.1 and 5%.[viii] Therefore, between 0.1% and 5% of specimens arriving at the laboratory will require more that the average one minute processing time. This adds significantly to laboratory overheads. As most pre-analytical errors are identified as occurring outside the laboratory walls, the implementation of electronic data capture at specimen source, with suitable checks to ensure patient identity and correct sampling procedures will contribute significantly to assuring patient safety, reduction in repeat sampling and consequently a more efficient and cost effective service for the patient.

Currently, pathology supply chains utilise only paper labels affixed to the specimen containers. In addition to having human-readable printed text, the labels also typically contain handwritten patient information and lab instructions packaged with the specimens. Such manual procedures are prone to errors and also expose patient related information to any person involved in the pre-analytical process.

Contribution to advancement of knowledge / technological progress

Related research [ix, x, xi, xii, xiii] has been completed to track pathology samples internally within a single location, and in the use of sensors to monitor the status of a specimen (i.e. temperature). However, no end to end “bedside to bench top” real-time system exists that integrates into health management systems using recognised protocols and standards. Currently the USA is leading the way in this area with some pilots completed internally within pathology laboratories. [xiv] Patents have also been filed regarding systems for the tracking of specimens within the laboratory, during the analytical phase. These existing systems are mere modifications of existing “track and trace” systems

A common problem that occurs is if smart object is exposed to inappropriate environmental conditions such as high temperatures; it becomes compromised and unusable. Many current systems do not facilitate the objects intelligently sensing their environmental change and collaborating to change their

environment. Existing systems objects may only be identified as compromised once a test is carried out, at which point no feedback is available to allow the identification of supply chain deficiencies.

Chain of custody is also an important aspect in smart object supply chain applications. Current systems in use are inappropriate because of a lack of visibility they cannot accurately report on chain of custody scenarios or any scenario where information relating to the actual movements of objects is required.

Research Methodology

Broad Methodology

The implementation of the project will be carried out in a staged approach, each of which is described below:

1. Stage 1 is designed to ensure that the project commences in the correct manner, in the right direction and with the required end result in mind. The literature review focuses on the existing research in this area and lead to developing and overall strategy required to ensure the development of a sound a robust methodology and to determine the requirements for the IOT architecture. The requirements design of the Smart Objects and Systems Intelligence ensures that all research and development activities are cognisant of the state of the art, applicable standards, data protection and privacy legislation and are designed with those at the forefront of thought.
2. The second stage involves the experimental research and development activity. At this stage the research and technical development of the integrated Architecture, Smart Objects and System Intelligence is performed. Within this second stage there is a strict interdependency between the individual work packages.
3. In the third stage, the experimental results from the research and development stage will be evaluated, to ensure that all aspects of the development are integrated and validated from a technological perspective.

PROJECT SCHEDULE – GANTT CHART

GANTT CHART	Year 1												Year 2					
Tasks	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Directed Study																		
Task 1.1 : Educational Development																		
Task 1.2 : Discipline-specific training																		
Framework/Architecture Development																		
Task 2.1 : Interactions with peers																		
Task 2.2: Actions performance																		
Smart Object Development																		
Task 3.1: Identify IoT technologies																		
Task 3.2: Mapping IoT to pathology Systems																		
Systems Intelligence, Integration and Validation																		
Task 4.1: Develop and deploy IoT Framework																		
Task 4.2: Identify intelligent requirements and mechanisms																		
Task 4.3: Incorporate intelligence into system																		
Privacy, Data Protection and Standards																		
Task 5.1: Define Goals and responsibilities																		
Task 5.2: Identify standard requirements and mechanisms																		
Academic Writing, Exploitation and Dissemination																		
Task 6.1: Write and submit Literature Review to Conference																		
Task 6.2:Present at ITT Seminar																		
Task 6.3:Present Demo at Conference																		
Task 6.4:Write Thesis																		
Task 6.5:Write Article																		
Task 6.6:Thesis Submission																		

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[viii] Specimen Labelling Errors. A Q-Probes analysis of 147 Clinical Laboratories. Wagar EA, Stankovic AK, Raab S, Nakhleh RE, Walsh MK. Arch Pathol Lab Med. Vol 132, October 2008, 1617-1622
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[x] http://www.rfidjournal.com/article/view/4422
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[xii] http://www.satoeurope.com/en/industry/healthcare_pharmaceutical/health_Hopsital_in_UK.html
[xiii] http://www.avantetech.com/products/supplychain/
[xiv] http://www.safetyleaders.org/pdf/Quality_initiative_decrease_pathology.pdf