The study for the enhancement of Waste Tracking System (WTS) using IoT

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1. Introduction

Radioactive Waste Tracking System (WTS) for KEPCO Nuclear Fuel (KNF) has been implemented and in operation. In addition to the original specification for electronic tracking system, there is trend and/or demand to converge Internet of Thing (IoT) technology in order to enhance the WTS that is reliable and efficient real-time system.

This paper provides the result and strategic plan for WTS enhancement by conducting the review of the radioactive waste management life cycle in Figure 1 and IoT that could be applicable in this process.

2. The radioactive waste management life cycle

According to the survey of waste process and management in the worlds, the waste stream to disposal could be simplified as indicated in Figure 1.

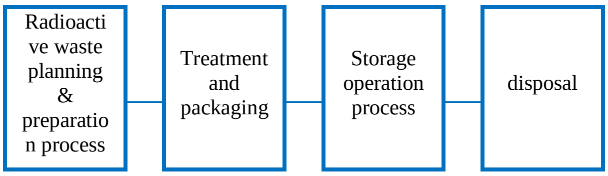

Figure 1 simplified waste management process[1]

It is expected that there are a lots of detail works to implement each process. Especially in treatment and packaging process they might have the following sub-activities for process implementation [2];

1) Collection by sorting, segregation and classification
2) Treatment and measuring (chemically, physically, radiologically and thermally)
3) Conditioning and/or immobilization for packing
4) storage operation, transport and delivery

Also in storage operation process, there is movement and transport requirement, and management between storage classes such as raw waste storage, conditioned storage, buffered storage and decay storage.

1 Radioactive waste management life cycle could be different though, but it has been proposed to ISO TC85 SC5 WG5 for New Work Item Proposal (NWIP) [1]

Considering all of this process and sub-process, the study has tried to find out the spot for application of IoT by taking a look at IoT reference model in Figure 2.

3. The considerations for IT convergence

In each process in Figure 1, the element that has potential possibility of automation could be converged with information technology (IT). In order to find the spot for IoT application, the study has analyzed the requirements, activity and outcome of each process for radioactive waste management life cycle, and comparing IoT reference model Figure 2 below. And then the selective and applicable level of reference model and its relevant technology has been listed up for development.

This study surveyed the infrastructure of WTS to review the possibility of IoT technology application, and it is decided that some level of IoT reference model, selective and graded approach are desirable to converge IoT into WTS.

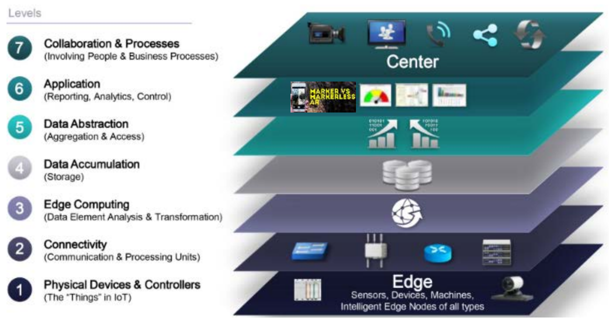

Figure 2 IoT reference mode

Because the infrastructure of WTS operation environment has not been established in consideration of IoT reference model and upgrade, typical area of IoT application is as below, but not limited to this;

a) IP based and/or non-IP based measured data acquisition and appropriate computing corresponding to level 1 through 3. In case of non-IP based data acquisition, the products compliant to IEC 61131[4] series of standard could be an option for connectivity between physical devices and edge computing entity. To assist this level of IoT convergence, a various serial and communication middleware for connecting heterogeneous devices together should be designed.

b) Data visualization using augmented reality (AR), mobilization, reporting, data warehousing and mining using tools and other operating aids from level 4 through 7 to formulate the meaningful data.

3.1 IIoT convergence level

As a result of analysis, a couple of integrated IoT level and its technology is selected. Based on Figure 2, level 1, 2, 3, 6 and 7 might be a candidates to be selected, and its specific technologies includes smart sensing through IP and/or non-IP based, and augmented reality with maker and/or markerless augmented reality application.

a) On-line direct upload of waste process data

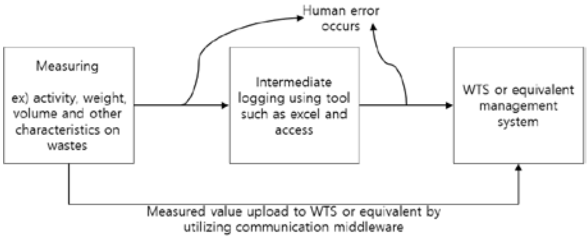

Figure 3 digital upload without human intervention

This topic was not requirement in existing system specification. But judging from the past experiences from the characteristics testing in solidified radioactive waste, there are a lots of test and measure results that is not currently directed to WTS server. It means the test and measure data is logged in excel file temporarily at first time, and put into WTS server database manually, which causes a waste of time and human error in WTS data management.

Considering the amount of data generated during radioactive waste management life cycle, it is highly recommended that the communication middleware between radioactive measuring instruments and WTS server to directly upload the test and measured data into WTS server should be implemented and equipped with system.

If human is involved in sequence in Figure 3, we has experienced the human error in recording the measured values and transcribe it. To eliminate this problem, it is necessarily to upload the measured data to WTS directly without human intervention by utilizing communication middleware, which might be coordinated with vendor of specific measuring equipment and devices.

b) Transport location tracking

It is assumed, different for each Member States though, that there are different type of storages including the final disposal such as geological disposal. To transport the identified waste unit like drum, a location with general information should be tracked down in real-time way if necessary, which is closely related to c) below.

c) Storage operation planning and monitoring

This is another type of IoT convergence between radioactive waste storage operation and AR with markerless methods. Using AR, the maintenance and operation of storage would be easier and consistent, and responsive for unexpected events. Engineer can simulate the storage administration by rearrangement and movement of waste units in remote way.

3.2 Statistical information governance

Using lots of data mining tool, a lot of data analysis and visualization is provided in various ways for efficient radioactive waste management. Effective and robust information and knowledge management systems are necessary for the development of strategic opportunities for the implementation of the baseline plan. Furthermore, knowledge retention over very long timescales, such as many decades to a century or more, is an essential consideration.

The ultimate product of radioactive waste management is a waste package and its associated waste package record. The waste package record has to support future operations over the lifetime of the waste package namely interim storage, transport and disposal. The requirements around what information constitutes a waste package record for each step are broadly the same but there are some specific differences and so each life cycle step must be considered [3].

6. Conclusions

Through the convergence of IoT technology, WTS could be more reliable and efficient system for stakeholder, and it is necessary to consider how to apply and optimize the IoT-based technology in radioactive waste management life cycle.

REFERENCES

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[3] Nuclear Decommissioning Authority (NDA), integrated waste management-radioactive waste strategy, 2018, Doc. Ref: ST/STY(18)0049

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