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Implementing blockchain technologies in NMAC system

Emerging technologies have focused on blockchain technology. Its growing use in the industry motivates the review of possible applications in the nuclear production. For instance, the French Atomic Energy Commission (CEA) developing a blockchain solution to increase trust in the food and Rosatom (Russia) invest in R&D on blockchain to safeguard military assets.

On the other hand, the IAEA has developed a general guide on the use of a nuclear material accounting and control (NMAC) system in support of nuclear safety at the facility level. The objective of these control measures is to maintain the continuity of nuclear knowledge in order to detect unauthorized waste, involving people with access to sensitive information. The control of nuclear material is carried out during the production, processing, use, storage and, movement of the same.

The contribution of this work is the implementation of the NMAC system using blockchain. In this sense, blockchain is a technology that could be used to archive the completed control and accounting to provide transparency in each step of NMAC. Also, it is a perfect tool to avoid proliferation issues.

Blockchain constructs a chronological chain of blocks, hence the name "block-chain". Each block is an immutable information unit. Also, Blockchain consists of timestamping of transactions, Peer-to-Peer networks, cryptography, and shared computational power.

Each nuclear material custodian is responsible for one-material-balance area. An area in a nuclear facility is a location where the quantity of nuclear material in each movement can be determinate. That is why the different material balance areas are the basis for NMAC system for all nuclear material in the facility. The quantity and attractiveness of the nuclear material determine the control type applied for its protection.

The guide about NMAC, advices that a registry documenting the implementation of all control measures of nuclear materials must be kept. These records must include a brief description of each nuclear material control activity, the signatures of the personnel who carry out the activities and the dates in which they were carried out. The registry must be kept secured and must be available to those who require access to them in the event of an irregularity or when an audit of the nuclear material control system is conducted.

Nuclear material control measures include, but are not limited to, control of access, material containment, tamper indicating devices (TIDs), nuclear material surveillance, monitoring of nuclear material items, monitoring of nuclear material during processing, and physical inventory taking.

The use of TIDs with a unique identification feature provides a level of confidence that the item protected by it has not been opened. During nuclear material movements, TIDs may be applied to nuclear material containers, shipping containers, and the transport vehicle cargo compartment, to provide for both the shipping and the receiving entity that the container and compartment integrity of the containment has not been violated. The TIDs are commercially available as, for example, electronic radio frequency tags. The limitation is that a TID could be replaced, removed, reapplied, or altered without leaving any indications of tampering. As a consequence, blockchain technology is presented as an unparalleled solution to ensure the registration of each activity carried out on a unit of nuclear material.

Operations involving nuclear material should be authorized and planned appropriately. There should be clear communication and sharing of information, among: management, NMAC, physical protection, safeguards, safety, and operations personnel regarding operations involving nuclear material (particularly with the confidentiality of sensitive information). Blockchain technology helps store and verify information in a decentralized way, using cryptographic techniques, where each transactional block is timestamped.

Accordingly, blockchain technology is a perfect digital solution to carry out the control of nuclear material. The business network should be composed of: each material-balance area custodian, the facility manager, and the nuclear authority to track the movement of nuclear-material. Each participant is able to access and work upon information about nuclear material store in a block. It could be possible to specify which is the nuclear element involved, its category, what kind of physical control should be exercised, the nuclear material custodian, the balance area, TID code, in each block of the chain. However, digital signatures could be used; however the block hash should be enough. The implementation of this scenario is simulated using IBM Hyperledge Framework.

As a brief conclusion of this work, blockchain technology promises an NMAC system efficient and transparent. Respectly to information security, being a distributed database, availability is guaranteed. Blockchain helps solve the vulnerabilities introduced with the use of TIDs since every activity carried out on a unit of

nuclear material is recorded in a timely manner.

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