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Enhancing the Security and Traceability of Radioactive Material Transport for Well Logging Applications through QR Code and Geo-Tagging Integration

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Indonesia's Nuclear Energy Regulatory Agency (BAPETEN) currently utilizes the Bapeten Licensing and Inspection System Online (Balis Online), a web-based platform integrated with the Indonesia's Online Single Submission - Risk Based Approach (OSS-RBA), to manage the licensing of nuclear activities. This system includes the transport of radioactive materials, a frequent activity in various industries. The well logging sector was specifically selected as the focus for this project due to several key factors: a historically high level of compliance with licensing and reporting requirements, a more established radiation safety and security infrastructure, and the significant involvement of multinational corporations that adhere to stringent international standards. This sector is characterized by the high mobility of radioactive sources, which presents unique regulatory challenges. The current protocol requires operators to secure transport approval and submit periodic reports via Balis Online. While this system documents the initial and final locations, it lacks the capability for real-time tracking of radioactive sources during transit. This reliance on periodic reporting presents a significant gap in ensuring continuous traceability and security oversight.

To address this challenge, this paper proposes the integration of an end-to-end tracking system into the Balis Online platform, leveraging the synergistic capabilities of QR Code and Geo-tagging technologies. These technologies are proven to be robust, user-friendly, and cost-effective, with widespread successful implementation in the logistics sector. In the proposed framework, the QR Code serves as a unique digital identifier for each radioactive package, encoding critical information such as the radionuclide type, serial number, and activity. Simultaneously, Geo-tagging provides real-time location tracking by capturing precise GPS coordinates and timestamps at each scanning point.

The operational workflow begins when a transport permit is issued, at which point Balis Online generates a unique QR code that the licensee prints and affixes to the package. Authorized personnel then scan the QR code at the point of departure and at every subsequent key transit point (e.g., warehouses, ports, airports). Each scan transmits the location and time data to a centralized Monitoring Dashboard. Upon arrival at the final destination, a concluding scan updates the transport status to "completed." This automated process creates a verifiable and transparent digital ledger of the material's entire journey, offering a more valid and reliable oversight mechanism than traditional periodic reporting.

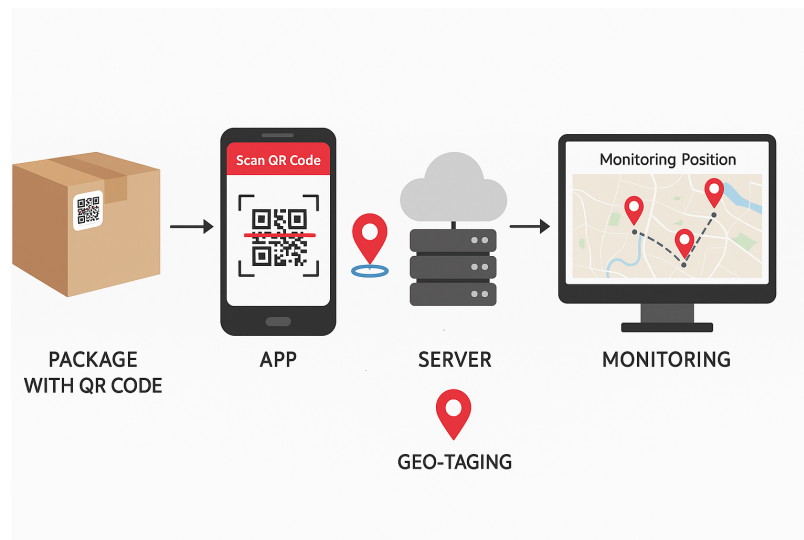


Fig. 1 Integrasi QR Code and Geo Tagging

The successful implementation of this system depends on four critical components: (1) an intuitive and integrated monitoring dashboard within Balis Online for efficiency; (2) a scalable and secure server infrastructure for data management; (3) comprehensive training for personnel on the new scanning protocols; and (4) robust data security, achieved through an authenticator application that restricts scanning privileges to authorized users with unique credentials. By adopting this technological solution, regulatory oversight becomes significantly more effective and efficient, substantially strengthening the safety and security framework for the transportation of radioactive materials.

Keywords: Radioactive material, Transport security, Real-time tracking, Well logging, QR Code, Geo-tagging, Regulatory oversight