DESIGN AND IMPLEMENTATION OF FLOOD MONITORING AND WARNING SYSTEM BASED ON INTERNET OF THINGS

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis, and in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Master of Science.

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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I hope my thesis is completed, received, and provides a good impact on society.

ABSTRAK

Banjir merupakan fenomena yang tidak dapat dielakkan yang boleh menyebabkan kehilangan nyawa dan kemusnahan infrastruktur. Banjir kilat meningkat dengan cepat di kawasan yang sering dilanda banjir, yang mengakibatkan kerosakan harta benda, tetapi kesan kepada manusia boleh dicegah dengan adanya sistem pemantauan banjir. Walaupun terdapat banyak sistem yang digunakan secara meluas oleh agensi pengurusan bencana alam dalam memantau banjir, kebanyakan sistem ini memiliki jarak yang terhad. Sebagai contoh, sesetengah sistem yang menggunakan Rangkaian Kawasan Luas Jarak Jauh (LoRaWAN) mempunyai jarak maksimum 300m daripada alat penerima. Bagaimanapun, jarak maksimum yang boleh dicapai oleh LoRaWAN ialah 1.5km. Kemudian, kajian pada parameter yang ada pada LoRaWAN untuk Sistem Pemantauan and Amaran Banjir (FMWS) adalah terhad. Tambahan pula, kebanyakan negara membangun, pintu air konvensional di saluran air dikendalikan secara manual dan mengalami kekurangan pemantauan serta merta mengenai paras air yang mungkin menyebabkan limpahan di terusan dan berlakunya banjir kilat. Selain itu, kekurangan analisis data dalam sistem yang boleh diakses adalah salah satu kekurangan di Malaysia. Oleh itu, penyelidikan ini mencadangkan menghasilkan dan menggunakan beberapa peranti pintar berasaskan modem Jarak Jauh (LoRa) dengan peranti penerima LoRaWAN sebagai rangkaian ujian untuk memantau tahap banjir, dan untuk menilai parameter LoRaWAN. Kemudian, pengaktifan LoRaWAN dibandingkan dan dianalisis untuk mengenal pasti pengaktifan yang terbaik untuk FMWS. Akhir sekali, penilaian secara maya mengenai risiko akibat paras banjir telah Berjaya menmencetuskan amaran awal banjir melalui aplikasi Tago.IO. FMWS yang dicadangkan dengan LoRaWAN menggunakan sensor ultrasonik dengan Arduino untuk mengukur paras air, LoRa sebagai modul komunikasi dan satu peranti penerima data. Peranti pengesan banjir telah diuji dalam beberapa senario untuk menguji prestasi komunikasi FMWS dari segi Petunjuk Kekuatan Isyarat Diterima (RSSI), Nisbah Bunyi Isyarat (SNR), kelewatan dan Peratusan Data Diterima (PDR). Reka bentuk peranti melibatkan perkakasan dan perisian dengan panel solar sebagai sumper kuasa. Model 3 Dimensi (3D) untuk peranti telah dibangunkan untuk meletak peranti pengesan banjir. Kawasan ujian untuk menguji prestasi LoRaWAN ialah 2km radius. Sepanjang ujian, sistem yang digunakan berjaya berkomunikasi sehingga 2km. Selain itu, kes yang dimana beberapa peranti digunakan mempunyai nilai SNR keseluruhan yang lebih tinggi berbanding dengan hanya menggunakan satu peranti di mana 56% daripada semua keputusan adalah positif untuk beberapa peranti digunakan manakala satu peranti sahaja hanya 50% sahaja. Tambahan lagi, RSSI dan SNR memberi kesan keatas nilai PDR. Walau bagaimanapun, kelewatan (delay) mempunyai hubungan secara berbalik dengan RSSI, SNR dan PDR.Pengaktifan yang disyorkan untuk FMWS ialah Pengaktifan Melalui Pemperibadian, (ABP) kerana ia menberi kawalan penuh terutamanya untuk mencapai PDR yang tinggi. Akhir sekali, data pada Tago.IO telah diakses melalui halaman web dan aplikasi mudah alih. Kesimpulannya, FMWS berkemampuan untuk berkomunikasi pada jarak 1.5km. Walau bagaimanapun, semakin tinggi SF, semakin tinggi prestasi untuk FMWS yang dicadangkan. ABP ialah pengaktifan yang sesuai untuk FMWS yang dicadangkan. Akhir sekali, system amaran akan dicetuskan apabila paras air mencapai paras amaran.

ABSTRACT

Floods are unavoidable phenomena that can cause massive loss of people's lives and the destruction of infrastructure. Flash floods rise rapidly in a flood-prone area, which results in property damage, but the impact on human lives is somewhat preventable by the presence of monitoring systems. Although there are many systems widely in practice by disaster management agencies in monitoring flood levels, most of these systems are limited in range. For example, some systems implementing the Long-Range Wide Area Network (LoRaWAN) have a maximum distance of 300m from the gateway. However, the maximum distance that LoRaWAN can reach is 1.5km. Then, the study on the parameter that involved in LoRaWAN for the Flood Monitoring and Warning System (FMWS) is limited. Furthermore, in most developing countries, the conventional flood gates in water canals are manually operated and suffer from the lack of real-time monitoring of water levels which might lead to an overflow in the channels and flash floods. On top of that, the lack of real-time data analysis in the system that can be accessed is one of the limitations in Malaysia. Therefore, this research design and implementation multiple LoRa-based smart sensors with a LoRaWAN gateway as a network testbed for monitoring flood levels and evaluating the parameter of LoRaWAN. Then, the LoRaWAN's activation was compared and analysed to identify the best activation for the FMWS. Lastly, the real-time assessment of the risk due to the flood level has been enabled on the Tago.IO dashboard for triggering an early flood warning. The proposed FMWS with LoRaWAN uses an ultrasonic sensor with an Arduino microcontroller to measure water level, Long-Range (LoRa) as a communication module, and a single gateway. The end nodes have been tested in several scenarios to test the FMWS's communication performance in terms of Received Signal Strength Indication (RSSI), Signal Noise Ratio (SNR), delay, and the Percentages of Data Received (PDR). The design of the sensing node involved the hardware and software with the solar panel as the power source. A 3 Dimension (3D) model for the end node was developed for casing the sensing node. The testing area for testing the performance of LoRaWAN is a 2km radius. Throughout the testing, the proposed system communicates up to 2km in single and multiple node cases. On top of that, the multiple nodes have higher overall SNR value compared to the single node where 56% of all result are positive for multiple nodes while the single node exhibit only 50%. In addition, the RSSI and SNR have impact on the PDR. However, the delay inversely perorational with RSSI, SNR and PDR values. The recommended activation for FMWS is Activation By-Personalization, (ABP) since it is over complete control, especially for achieving a high PDR. Lastly, the data on Tago.IO was accessed via webpages and Tago.IO mobile application. In conclusion, the FMWS able to communicate to the gateway at 1.5km distance. However, the higher the SF, the higher the network's performance at long distances. The ABP is the activation that is suitable for the proposed FMWS. Lastly, the warning system will trigger once the water level reaches the warning level.

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