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Conclusion

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DOI
10.1007/978-3-030-85836-0_8

Publication date
2021

Document Version
Final published version

Published in
SpringerBriefs in Applied Sciences and Technology

Citation (APA)
Kashyap, S., Rao, V., Venkatesha Prasad, R. R., & Staring, T. (2021). Conclusion. In *SpringerBriefs in Applied Sciences and Technology* (pp. 85-86). (SpringerBriefs in Applied Sciences and Technology). Springer. https://doi.org/10.1007/978-3-030-85836-0_8

Important note
To cite this publication, please use the final published version (if applicable).
Please check the document version above.

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Chapter 8
Conclusion

This research focused on enabling Internet connectivity to a new generation of smart kitchen appliances that work on wireless power technology. In order to provide efficient and seamless communication with the appliances, the possibilities of utilizing the NFC channel for Internet connectivity were explored. Two architectures called proxy and bridge were proposed to enable connectivity via a time-slotted NFC channel of the cordless kitchen. The bridge architecture was adopted for the cordless kitchen as it implements the full TCP/IP stack on the appliance and provides it more control over the TCP communication.

As most of the IoT applications use the TCP/IP protocol, this work mainly focused on adapting the TCP/IP protocol to the cordless kitchen system. Two major problems, namely spurious retransmissions and packet drops at the NFC interface, which arise while adapting TCP to the time-slotted NFC channel, were recognized and discussed in detail. To eliminate the spurious retransmissions, a generalized solution was provided to compute the optimum RTO values for TCP/IP packets tunneled over the NFC channel. Using this, the spurious retransmissions were completely removed in short TCP sessions. As TCP does not consider the payload sizes for RTO estimation, spurious retransmissions were observed when there was high variability in payload sizes. To mitigate this, a new algorithm was proposed that dynamically estimates and updates the RTO of the packets considering the payload sizes and changing channel delays. This algorithm provided a more accurate estimation of the RTO values compared to VJ's algorithm used in the LwIP stack. A reduction of about 29.32% in latency was observed with this algorithm for the data set considered. To avoid packet drops at the NFC module caused due to small inter-packet delays, an NFC channel sensing mechanism was introduced in the cordless kitchen system. This mechanism eliminated all the retransmissions that existed due to packet loss at the NFC interface. Using all these techniques, up to 38% reduction in the system latency is achieved at an NFC bit rate of 11.2 kbps and up to 53% at 24 kbps.

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S. Kashyap et al., *Cook Over IP*,
SpringerBriefs in Applied Sciences and Technology,
https://doi.org/10.1007/978-3-030-85836-0_8

A comprehensive performance analysis was made with respect to different parameters of TCP/IP that affect the system performance such as the TCP RTO value, MSS and CWND size. Take-aways of this study include (a) initial CWND size does not have a significant impact on the system latency and (b) recommended MSS value is $\geq$ 1024 bytes to get a good performance. The research also analyzed the effects of non-TCP/IP factors on the system performance such as NFC bit error rates, communication time-slot sizes and influence of transferring other control messages along with TCP/IP packets over the NFC channel. It concluded that the system has relatively better performance with bursty errors in the NFC channel than with random bit errors. It showed that close to 99% data transmission efficiency can be achieved with a slot size of 1.9 ms at higher NFC bit rates. The results also showed that if the frequency of non-TCP/IP messages on the channel stays under 50%, a transmission efficiency of 75% can be achieved. By adopting the proposed architectures with improvement techniques and recommendations, Internet connectivity can be enabled in the cordless kitchen system using its time-multiplexed NFC channel.

Reference

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