COLLEGE OF ENGINEERING AND COMPUTER SCIENCE
FLORIDA ATLANTIC UNIVERSITY

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for the degree of Doctor of Philosophy (Ph.D.)

"A Reference Architecture for Network Function Virtualization"

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ABSTRACT OF DISSERTATION
A Reference Architecture for Network Function Virtualization

Cloud computing has provided many services to potential consumers, one of these services being the provision of network functions using virtualization. Network Function Virtualization is a new technology that aims to improve the way we consume network services. Legacy networking solutions are different because consumers must buy and install various hardware equipment. In NFV, networks are provided to users as a software as a service (SaaS). Implementing NFV comes with many benefits, including faster module development for network functions, more rapid deployment, enhancement of the network on cloud infrastructures, and lowering the overall cost of having a network system. All these benefits can be achieved in NFV by turning physical network functions into Virtual Network Functions (VNFs). However, since this technology is still a new network paradigm, integrating this virtual environment into a legacy environment or even moving all together into NFV reflects on the complexity of adopting the NFV system. Also, a network service could be composed of several components that are provided by different service providers; this also increases the complexity and heterogeneity of the system. We apply abstract architectural modeling to describe and analyze the NFV architecture. We use architectural patterns to build a flexible NFV architecture to build a Reference Architecture (RA) for NFV that describe the system and how it works. RAs are proven to be a powerful solution to abstract complex systems that lacks semantics. Having an RA for NFV helps us understand the system and how it functions. It also helps us to expose the possible vulnerabilities that may lead to threats toward the system. In the future, this RA could be enhanced into SRA by adding misuse and security patterns for it to cover potential threats and vulnerabilities in the system. Our audiences are system designers, system architects, and security professionals who are interested in building a secure NFV system.

BIOGRAPHICAL SKETCH
Born in Saudi Arabia
B.S., Taibah University, Medina, Western Region, Saudi Arabia, 2010
M.S., Florida Atlantic University, Boca Raton, Florida, 2016
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CONCERNING PERIOD OF PREPARATION
& QUALIFYING EXAMINATION

Time in Preparation: 2016 - 2020

Qualifying Examination Passed: Spring 2017

Published Papers:

1. **A. M. Alwakeel, A. K. Alnaim, and E. B. Fernandez, "A Survey of Network Function Virtualization Security," in *IEEE SoutheastCon 2018*, 2018, doi: 10.1109/SECON.2018.8479121.**
2. **A. M. Alwakeel, A. K. Alnaim, and E. B. Fernandez, "Analysis of threats and countermeasures in NFV use cases," in *SysCon 2019 - 13th Annual IEEE International Systems Conference, Proceedings*, 2019, pp. 1–6.**
3. **A. M. Alwakeel, A. K. Alnaim, and E. B. Fernandez, "Toward a Reference Architecture for NFV," in *2nd International Conference on Computer Applications and Information Security, ICCAIS 2019*, 2019.**
4. **A. M. Alwakeel, A. K. Alnaim, and E. B. Fernandez, "A Pattern for Network Function Virtualization Infrastructure (NFVI)," in *In Proceedings of the 26th PLoP'19*, 2019.**
5. **A. M. Alwakeel, A. K. Alnaim, and E. B. Fernandez, "A Pattern for a Virtual Network Function (VNF)," in *The 14th International Conference on Availability, Reliability and Security (ARES 2019)*, 2019.**
6. **A. M. Alwakeel, A. K. Alnaim, and E. B. Fernandez, "A Pattern for NFV Management and Orchestration (MANO)," in *Proceedings of the 8th Asian Conference on Pattern Languages of Programs*, 2019.**
7. **A. K. Alnaim, A. M. Alwakeel, and E. B. Fernandez, "A Pattern for an NFV Virtual Machine Environment," in *Proceedings of the 13th Annual IEEE International Systems Conference 2019*, 2019.**
8. **A. K. Alnaim, A. M. Alwakeel, and E. B. Fernandez, "Threats Against the Virtual Machine Environment of NFV," in *2nd International Conference on Computer Applications and Information Security, ICCAIS 2019*, 2019.**
9. **A. K. Alnaim, A. M. Alwakeel, and E. B. Fernandez, "A Misuse Pattern for NFV based on Privilege Escalation," in *Proceedings of the 8th Asian Conference on Pattern Languages of Programs*, 2019.**
10. **A. K. Alnaim, A. M. Alwakeel, and E. B. Fernandez, "A Misuse Pattern for Compromising VMs via Virtual Machine Escape in NFV," in *Proceedings of the 14th International Conference on Availability, Reliability and Security (ARES 2019)*, 2019.**
11. **A. K. Alnaim, A. M. Alwakeel, and E. B. Fernandez, "A Misuse Pattern for Distributed Denial-of-Service Attack in Network Function Virtualization," in *In Proceedings of the 26th PLoP'19*, 2019.**
12. **A. K. Alnaim, A. M. Alwakeel, and E. B. Fernandez, "Towards a Security Reference Architecture for Network Function Virtualization," 2020. (Submitted).**