Factors influencing the adoption of Software Defined Networking by Research and Educational Networks

Emergent Research Forum (ERF)

AMCIS 2019
Cancun, Mexico

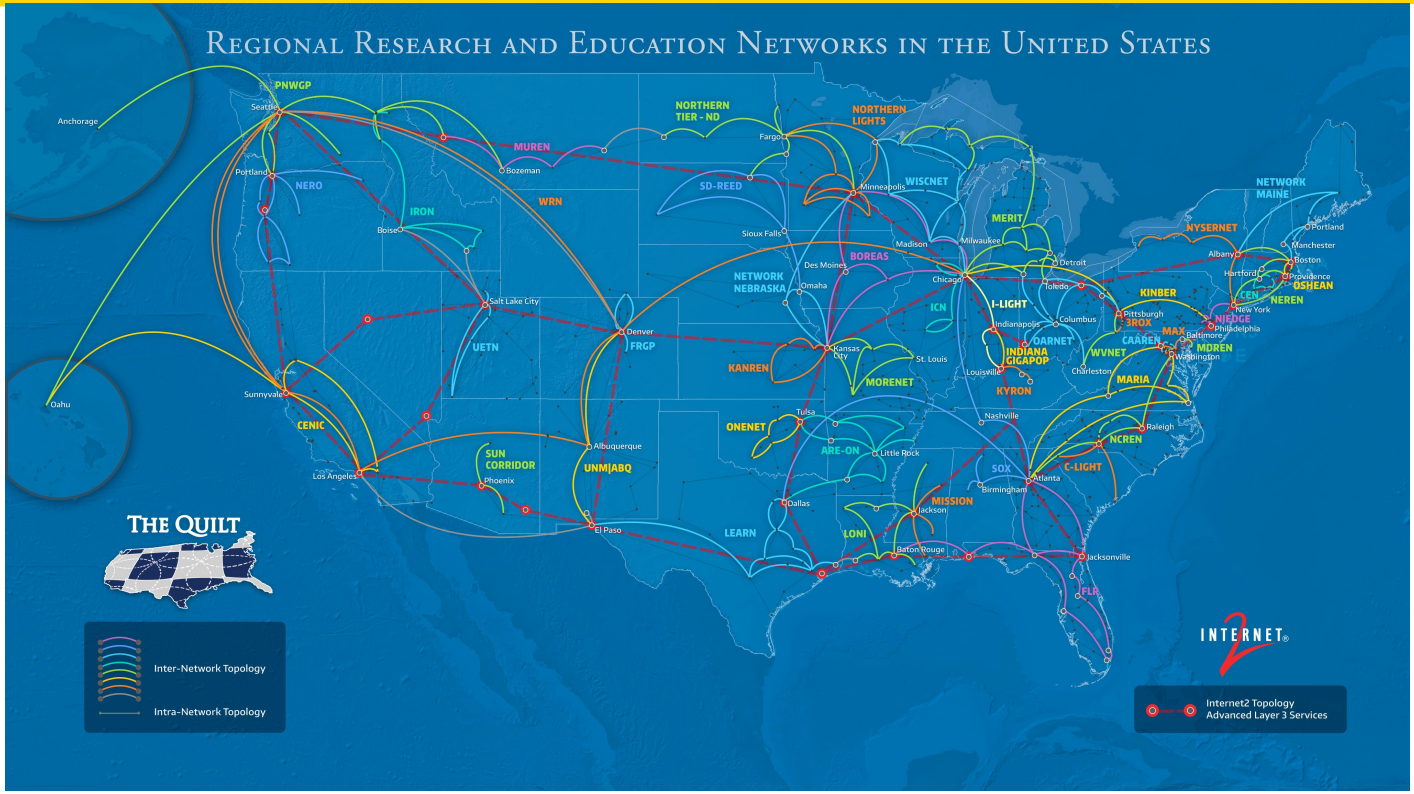
Vasilka Chergarova- Florida International University, Nova Southeastern University

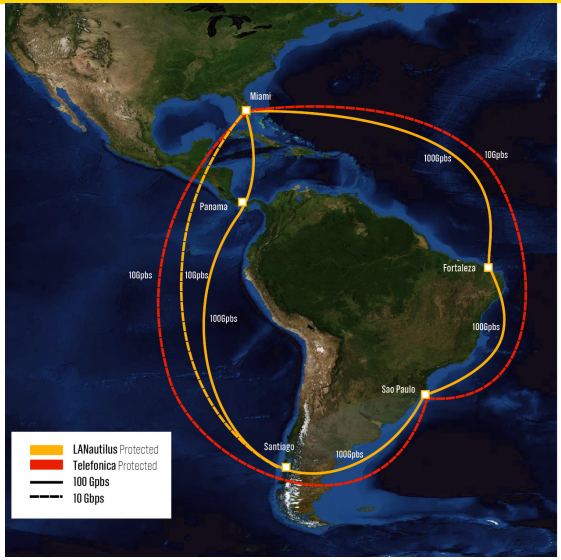
Jeronimo Bezerra- Florida International University

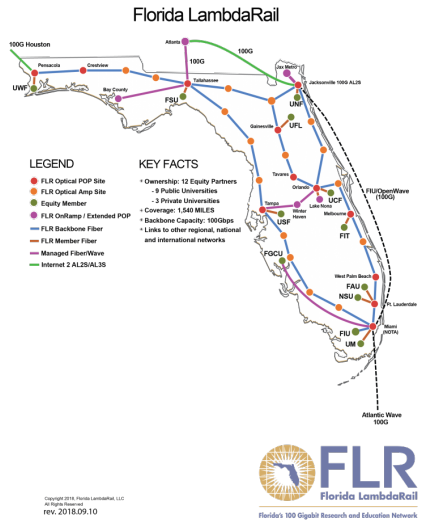
Julio Ibarra- Florida International University

Heidi Morgan- University of Southern California

Research and Educational Networks (RENs)

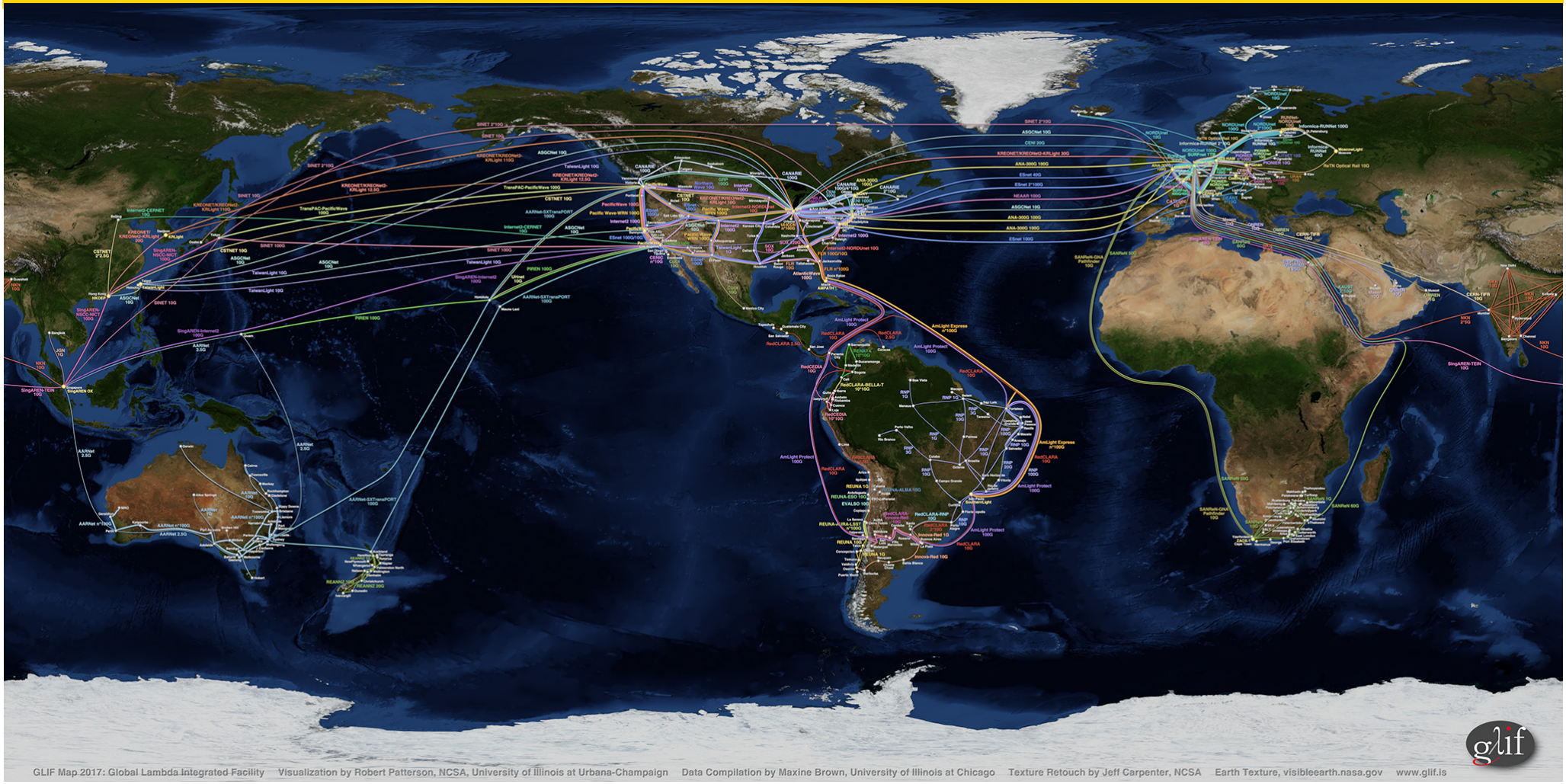






Definition: "Research and Educational Networks (REN) are non-commercial, specialized internet service providers who support services dedicated to the unique needs of universities and research institutes, including schools, hospitals, libraries, museums, and other national facilities" ("Why R&E Networks?," 2018)

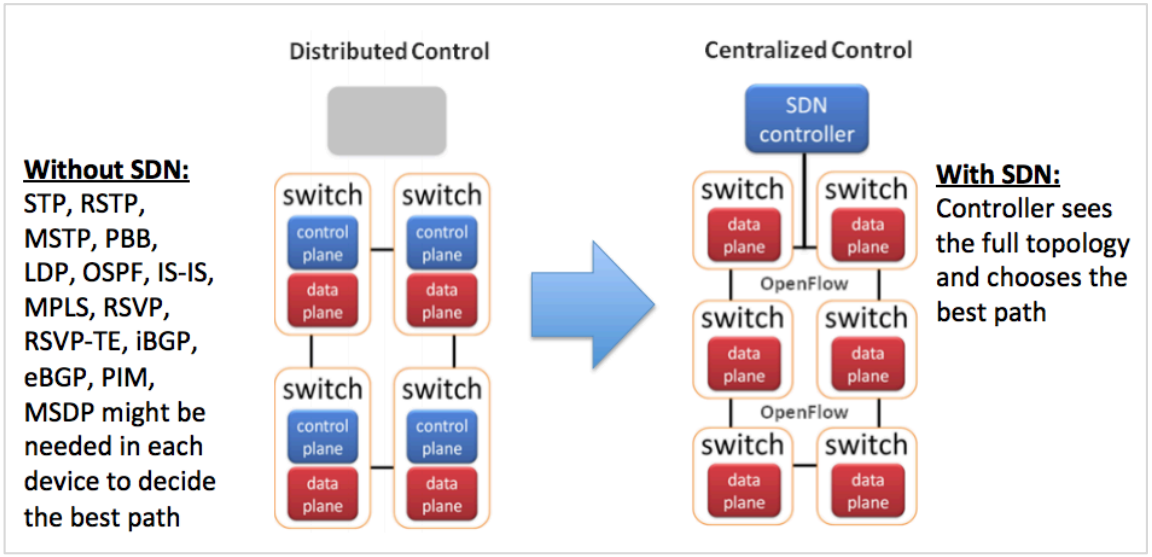
Global Research and Educational Networks (RENs)



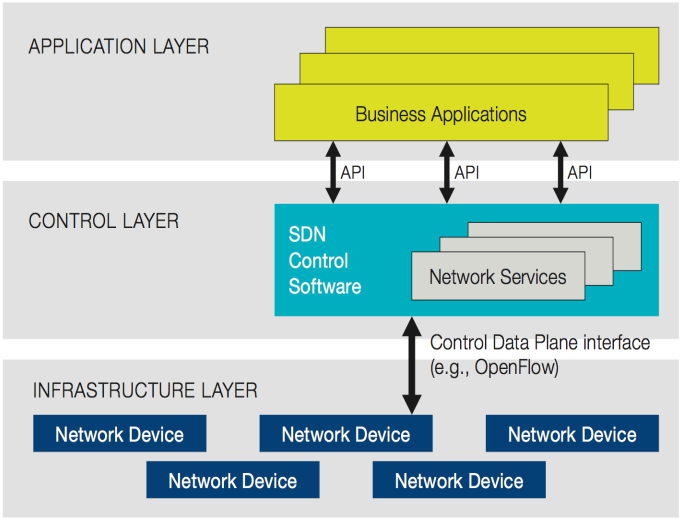
Acknowledgements - The Global Lambda Integrated Facility (GLIF) Map 2017 visualization was created by Robert Patterson of the Advanced Visualization Laboratory (AVL) at the National Center for Supercomputing Applications (NCSA) at the University of Illinois at Urbana-Champaign (UIUC), using an Earth image provided by NASA with texture retouching by Jeff Carpenter, NCSA. Data was compiled by Maxine D. Brown of the Electronic Visualization Laboratory (EVL) at the University of Illinois at Chicago (UIC). Support was provided by GLIF, NCSA/UIUC, the State of Illinois and the National Science Foundation award #ACI-1445176 for CADENS (Centrality of Advanced Digitally ENabled Science). For more information on GLIF, see http://www.glif.is/

What is SDN?

- **Legacy network:** The legacy way of providing service by the telecommunication industry is by deploying proprietary physical equipment (server, switch, router, etc.) for each function of the service, which enables long product life cycles, but low service agility and heavy dependence on specialized hardware (Mijumbi et al. 2016)
- **SDN:** SDN paradigm offers vertical separation of the network's control logic from the underlying routers and switches, promoting (logical) centralization of network control, and introducing network programmability (Kreutz et al. 2015)



Software Defined Networking. Adopted from "The Future Of The Network Is Software Defined " 2012. Retrieved from https://www.themetisfiles.com/2012/10/the-future-of-the-network-is-software-defined/

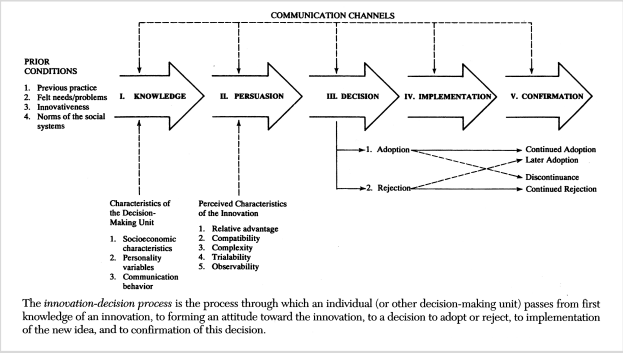


Software Defined Networking Architecture Model ONF (2012) Adopted from "Software-defined networking: The new norm for networks" 2012, Palo Alto, CA. Open Network Foundation, p.7. Copyright 2012 by ONF.

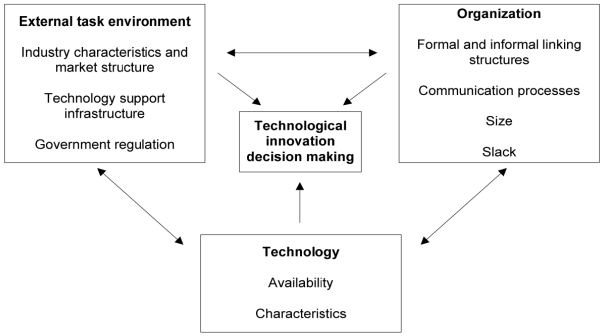
Research Problem and Research Question

- **Problem**: Adoption of SDN paradigm is slow, despite the suggested benefits of improved efficiency (Xia et al. 2015)
- SDN can deliver many cost-effective benefits to RENs, however, there is limited research on how RENs are adopting SDN.
- **Research Question**: What is promoting/blocking the adoption of Software Defined Networking with the Research and Educational Networks?

Theoretical foundation



Diffusion of Innovation (DOI) theory model (Rogers, 1962)



Technology, organization, and environment (TOE) framework (Tornatzky and Fleischer, 1990)

Human Factor:
1. Leader's opinion (+)
2. Team Skills (+)

Environment:
1. Regulation Policies (+)
2. Technology support (+)

Software Defined Networking Adoption by R&E networks

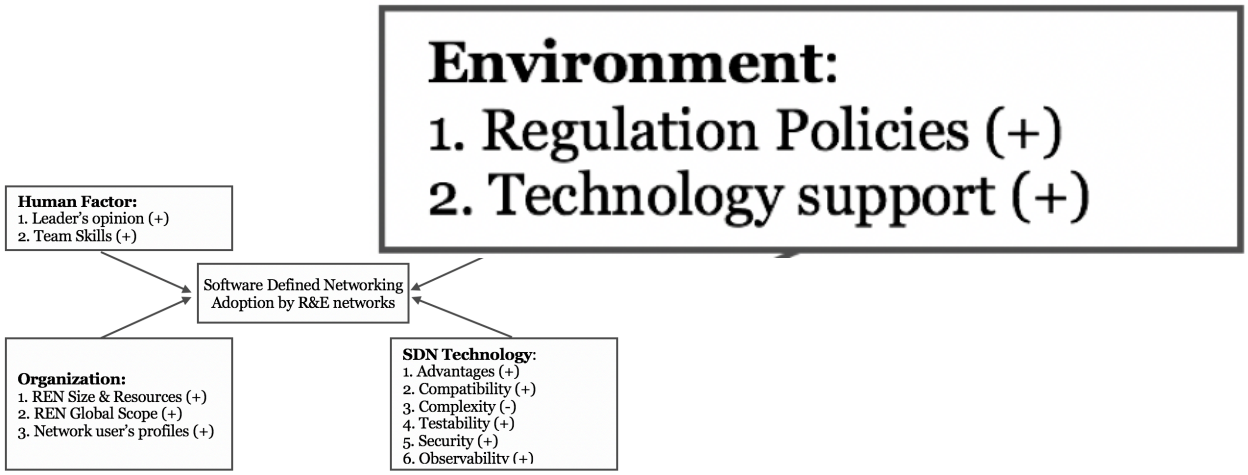
Organization:
1. REN Size & Resources (+)
2. REN Global Scope (+)
3. Network user's profiles (+)

SDN Technology:
1. Advantages (+)
2. Compatibility (+)
3. Complexity (-)
4. Testability (+)
5. Security (+)
6. Observability (+)

Proposed Theoretical Model

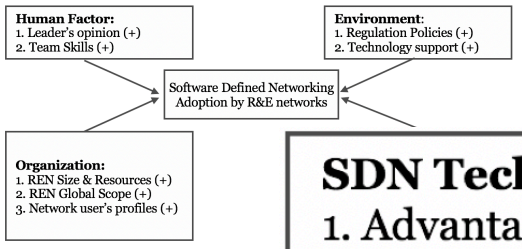
Propositions for Environment

1. The **more policy requirements** the REN has, the more the organization is prone to adopt SDN
2. The **vendor support for SDN capability** has a positive effect on the rate of adoption of SDN in RENs.



Propositions for SDN Technology

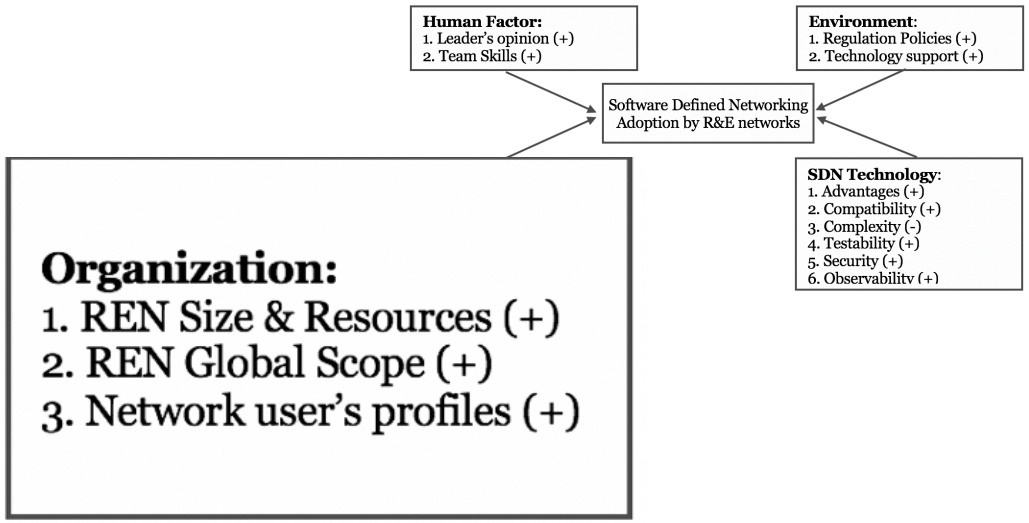
1. A higher level of perceived relative **advantages** of SDN has a positive effect on its adoption by RENs.
2. **Compatibility** with existing legacy networks increases the rate of adoption of SDN by RENs.
3. High **complexity** network technology negatively affects the SDN adoption by RENs
4. The more SDN components are **tested** before implementation in production, the higher the rate of SDN adoption
5. High level of **security** in SDN positively affects the rate of adoption by RENs.
6. The more **visible** the results of SDN are, the more likely to be adopted by RENs.



SDN Technology:
1. Advantages (+)
2. Compatibility (+)
3. Complexity (-)
4. Testability (+)
5. Security (+)
6. Observability (+)

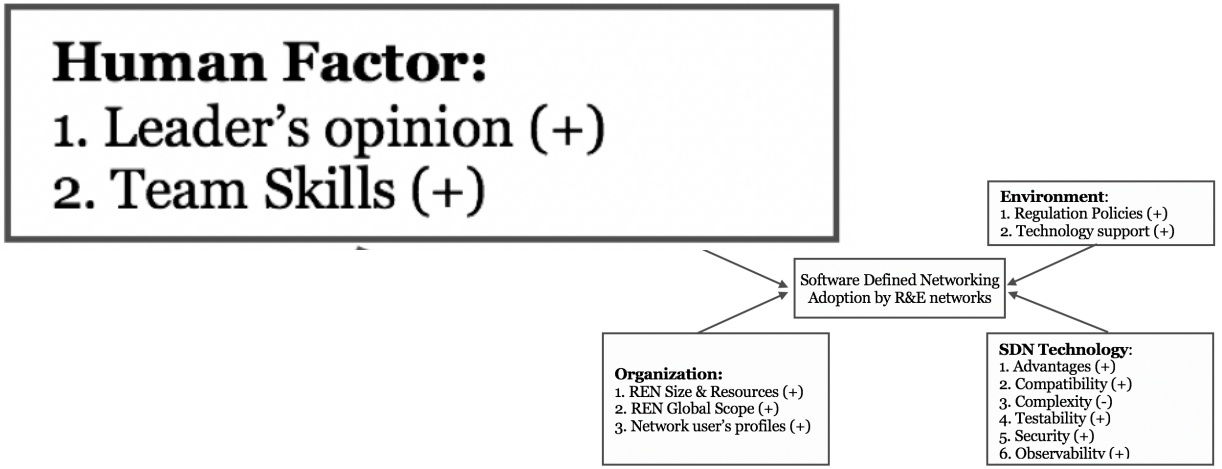
Propositions for Organization

1. The **size** of the REN positively affects the adoption of the SDN.
2. (**REN global scope**) A high number of big-data institutions connected via RENs positively affects the adoption of SDN.
3. The more complex the **user's network profiles** are, the more the REN is inclined to adopt the SDN.



Propositions for Human Factor

1. The more positive the **leader's attitude** towards innovation is, the greater the probability that the REN will adopt SDN.
2. Combined **programming and networking skills** positively affects the adoption of the SDN by RENs.



Conclusion

- SDN is a new paradigm and its adoption has been slow
- Next step is to create a survey instrument and test the propositions
- The results of this research will provide RENs planning to adopt SDN with more details

THANK YOU

Vasilka Chergarova
vc574@mynsu.nova.edu, vchergar@fiu.edu

This material is based upon work supported by the National Science Foundation under Awards #1451018 and #1451024 Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

References

- Abramovici, A., Althouse, W. E., Drever, R. W., Gürsel, Y., Kawamura, S., Raab, F. J., Shoemaker, D., Sievers, L., Spero, R. E., and Thorne, K. S. 1992. "LIGO: The Laser Interferometer Gravitational-Wave Observatory," *Science* (256:5055), pp. 325-333.
- Bakhshi, T. 2017. "User-Centric Traffic Engineering in Software Defined Networks." University of Plymouth.
- Bezerra, J., and Marcos, J. 2016. "Handling Network Events in a Production SDN Environment: The Amlight Use Case," *Internet2 Technology Exchange* , Miami: Internet2.
- Bilderbeek, P. (2012). The Future Of The Network Is Software Defined. Retrieved from https://www.themetisfiles.com/2012/10/the-future-of-the-network-is-software-defined/
- Chung, J., Cox, J., Ibarra, J., Bezerra, J., Morgan, H., Clark, R., and Owen, H. 2015. "Atlanticwave-SDX: An International SDX to Support Science Data Applications," *Software Defined Networking (SDN) for Scientific Networking Workshop, SC'15*, pp. 1-7.
- Del Rosso, A. 2012. "Higgs: The Beginning of the Exploration."
- Hoang, D. 2015. "Software Defined Networking? Shaping up for the Next Disruptive Step?," *Australian Journal of Telecommunications and the Digital Economy* (3:4).
- Howard, M. 2016. "Carrier SDN Strategies Service Provider Survey - 2016," Online, p. 22.
- Ibarra, J., Bezerra, J., Morgan, H., Lopez, L. F., Cox, D. A., Stanton, M., Machado, I., and Grizendi, E. 2015. "Benefits Brought by the Use of Openflow/SDN on the Amlight Intercontinental Research and Education Network," *Integrated Network Management (IM), 2015 IFIP/IEEE International Symposium on*: IEEE, pp. 942-947.
- Inder Monga, E. P., Chin Guok. 2012. "Software Defined Networking for Big-Data Science," *SuperComputing12 (SC12)*, Salt Lake City, UT: U.S. Department of Energy, Berkeley Lab.
- Jain, S., Kumar, A., Mandal, S., Ong, J., Poutievski, L., Singh, A., Venkata, S., Wanderer, J., Zhou, J., and Zhu, M. 2013. "B4: Experience with a Globally-Deployed Software Defined Wan," *ACM SIGCOMM Computer Communication Review*: ACM, pp. 3-14.
- Kreutz, D., Ramos, F. M., Verissimo, P. E., Rothenberg, C. E., Azodolmolky, S., and Uhlig, S. 2015. "Software-Defined Networking: A Comprehensive Survey," *Proceedings of the IEEE* (103:1), pp. 14- 76.
- Lipscomb, G. 2015. "Internet2 Implements First Large-Scale Deployment of ONOS in Live Network." Washington, DC: Internet2.
- Mijumbi, R., Serrat, J., Gorricho, J.-L., Bouten, N., De Turck, F., and Boutaba, R. 2016. "Network Function Virtualization: State-of-the-Art and Research Challenges," *IEEE Communications Surveys & Tutorials* (18:1), pp. 236-262.
- Nunes, B. A. A., Mendonca, M., Nguyen, X. N., Obraczka, K., and Turletti, T. 2014. "A Survey of Software- Defined Networking: Past, Present, and Future of Programmable Networks," *IEEE Communications Surveys & Tutorials* (16:3), pp. 1617-1634.
- ONF. 2012. "Software-Defined Networking: The New Norm for Networks," *ONF White Paper* (2), pp. 2-6.
- Roberts, G. 2014. "SDN in GEANT," *Whitehall SDN Conference*, London, UK: GÉANT, pp. 1-21.
  Rogers, E. M. 1962. *Diffusion of Innovation*. New York, Free Press of Glencoe.
- Rogers, E. M. 1995. *Diffusion of Innovation*, (Fourth Edition ed.). The Free Press. New York.
- Tornatzky, L., Fleischer, M., and Chakrabarti, A. 1990. "The Process of Technology Innovation. 1990," *Lexington: Lexington Books*).
- Why R&E Networks? (2018). *In the Field*. Retrieved from https://www.inthefieldstories.net/why-re-networks/
- Xia, W., Wen, Y., Foh, C. H., Niyato, D., and Xie, H. 2015. "A Survey on Software -Defined Networking," *IEEE Communications Surveys & Tutorials (17:1)*, pp. 27-51.