APPLICATION FORM

2020 SUMMER FACULTY GRANTS
SCHOOL OF ARTS AND SCIENCES

1. Faculty Name: Yang Wang

2. Department: Mathematics and Computer Science

3. Type of Grant: Faculty Student Research/Scholarship

4. For Faculty-Student Research/Scholarship:

a) IRB approval required? No

If Yes, IRB application status:

b) IACUC approval required? No

If Yes, IACUC application status:

5. For Experiential Learning Projects:

Has the proposal been preapproved Yes/No. (dropdown)

6. Project Description: (written for a general audience)

Please see Attachment A.

7. Timeline:

Including five phases as in our past research project:

1. May 14–31: Literature review on related research, and write summaries for selected papers; reflection on our prior research.

2. June 1–15: Tutorials on advanced techniques in network modeling, and network research methodologies; set up and familiarize with the new simulation environment.
3. June 16–30: Creation and discussion on mathematical models for the investigated problem. Given the complexity of the problem, multiple modelling choices may be considered.
4. July 1–31: Cycle of model implementation, tuning and re-implementation.
5. August 1–21: Evaluation, results collection and analysis; technical report/manuscript writing.

8. Anticipated Faculty Time Commitment:

I will spend a minimum of 216 hours on the project for the 12 weeks of summer beginning May 14, with an average of 18 hours per week. We note that these numbers are given as a minimum commitment; more time and efforts may be needed in the latter stages of this project for experiments and report/paper writing (which was the case in all my past summer research projects). We will adjust our meeting frequency accordingly, with minimum two to three meetings per week, and also actively exchange ideas via phone, e-mail, Canvas, and Google hangouts whenever new challenges come out.

9. Detailed Budget with Justification:

1. $3500 and $1500 for the faculty, and student stipends, respectively.
2. $1000 for purchasing PCs to setup a mesh network for the model simulation.

Justification:

The PCs are needed for three reasons:

i. The simulation tool, namely IBM CPLEX (https://www.ibm.com/products/ilog-cplex-optimization-studio) is a state-of-the-art solver for Integer Linear Programming (ILP) model. Running those models in CPLEX are not only time consuming (up to weeks) but also computational extensive. Thus even though new PCs do not affect the plausibility of the proposed project, dedicated high performance PCs are desired to guarantee the progress of project.

ii. I am developing a new course, namely Ethical Hacking, which will be offered for Fall 2020 for the first time. Preparing for this course will be greatly benefited with dedicated PCs with administrative privileges (due to the nature of the lab practices of this class).

iii. The purchased PCs will also add-on to the existing PCs (which are old retired faculty PCs) in the *Please-Touch* lab of *Holroyd* 150 that I created. This lab is used in a variety of courses when the university lab computers fail to provide the needed administrative privileges for experiments and exercises.

10. Faculty Summer Work Commitment: (administrative, teaching, and other)

None.

11. Expected Deliverables as a Result of this Grant: (e.g., publications, presentations, etc.)

As we have done in the past, the project will disseminate the results through workshop/conference presentations/proceedings, and journal publications. Jabree has worked me on the summer project of 2019, and we have a co-authored manuscript based on our findings of the project, which is currently under review for IEEE Transactions on Networking. Likewise, we expect this project will lead to the submission of at least one peer-reviewed proceedings paper or a peer-reviewed journal paper. Subject to the date/deadline of the conference, we may spend extra time for the manuscript preparation. Jabree had an experience of presenting his research project to the CSC 230 class that I teach, and it is expected that Jabree will also present his findings in this project (as a guest speaker) for the networking class that I teach or the ACM/Math Club. In addition, we will also seek external/internal supports for Jabree to attend networking conferences and present his work.

The following networking conferences are under our consideration for publication, where all the technical papers go through a rigorous peer-review process by at least three domain experts: IEEE Global Communication Conference, International Conference on Computing, Networking and Communications, and IEEE Sarnoff Symposium. Equally, we will seek for publication in the following journals: IEEE Communication Letters, IEEE Journal of Lightwave Technology, and Computer Networks.

Feedbacks/interactions from above leading networking conferences/journals will surely increase both the La Salle's reputation and the quality of our work.

It is also worth mentioning past experience in guiding undergraduate student research. My two advisees (Michael Mazzucca, and Phanvu Chau) that were supported by Summer Research Grant 2014 have jointly presented their research findings at the undergraduate poster day, the *Holroyd* Event as well as the 23rd International Wireless and Optical Communications Conference. As a guest speaker, Phanvu presented his findings at the CSIT 422 Information Security class in 2014. Phanvu also published two co-authored proceeding papers, and one co-authored journal paper in 2016 by the Elsevier Journal of Computer Networks (i.e., a journal ranked 14-th in the category of Computer Networks according to Google Scholar Journal Rankings). In Summer 2016, my two advisees, Zachary McNulty (who was supported by the Summer Research Grant) and Hung Nguyen (who has voluntarily worked with me) co-authored a journal article with me, which is published in 2017 by IEEE/OSA Journal of Lightwave Technology (a journal ranked as 6-th in the category of Optics and Photonics according to Google Scholar Journal Rankings). In Summer 2017, my advisee, Hung Nguyen, has co-authored two proceeding papers with me, which are published recently in the proceedings of the IEEE ICCCN conference and IEEE Sarnoff conference, respectively. As one of the best students from my CSC 230 class, Jabree Flor has demonstrated outstanding programming skills and was the only student that accomplished a bonus project. What is most impressed me is his consistent dedication and enthusiasm in Computer Science research. Since Fall 2018, Jabree has worked with me voluntarily and completed the summer research in 2019 with successful findings. We are both confident that this project will lead to new joint findings and publications.

12. Is this project supported by other grants/funding sources? No

If Yes, describe:

13. Faculty CV: (can paste in box below or upload separately to SASOffice@lasalle.edu)

Send separately as Attachment B.

14. For Faculty-Student Research Component: (If applicable)

a) Student Name(s): Jabree Flor, Class of 2022, Computer Science Major

b) Student Role in Project & Time Commitment: (1/2 page - written for a general audience)

Through this project, Jabree is expected to acquire and/or enhance the following abilities. First, review literature studies/manuscripts and provide critical comments and feedback. Second, combine and apply major network methodologies with creative ideas of his own. Particularly, as this is a second time summer research experience, Jabree is expected to play an even more active role in determining the methodologies that are used in the project. Third, evaluate networking protocols/algorithms via simulations, and analyses the finding with graphic tools. Fourth, professionally present research findings in both spoken and written forms.

As last project, Jabree will be assigned guided tasks in different phases: Phase 1: Write summary for important related work of this project, which has already started since Fall 2019 and continued ever since; Phase 2: Reflection, training and practices via a Canvas course and group meetings on major networking research methodologies and other advanced topics in networking research; Phase 3: Create models with gradually increased complexity for the studied problem; Phase 4: Implementation and tuning of models with the solver software CPLEX; Phase 5: evaluation and analyze results in graphic tools such as Visio, GNUPlot, and technical report/paper writing in IEEE with professional tools such as Latex.

Jabree has voluntarily worked with me since Fall 2018 on various projects, and has completed at least five network modeling tasks in the recent semesters. With no lead time, Jabree will spend a minimum of 144 hours on the project, with an average of 12 hours per week on the project during each of the twelve weeks.

c) Student-authored Statement of Interest

"*As I continue with my education into Computer Science my passion only grows stronger, because every step I take now is one step closer to my end goal which is to be able to say*

confidently that I left my mark on the world. I want to be able to change lives with something that I have either discovered or created, and I had the opportunity to take a step toward my goal last year when I was able to work with Dr. Wang on our research assignment. Dr. Wang prior to the summer research had assigned several articles to read to get an understanding of what I would be heading into, and to expand my knowledge on the field. This gave me the opportunity to immediately begin working with the language C. Prior to the summer research I had never worked with C, so that was one of the first tasks that I had to accomplish. After learning more about the language and throughout the summer Dr. Wang would assign me different problems to work on to continue building my skill and knowledge. Some of these problems include the shortest path problem, the multi-commodity flow problem, and the vertex cover problem. Through these problems I would develop the ability to solve problems through link-based and path-based solutions. They would also allow me to understand how to develop a goal and use constraints to yield a solution for the new problem of this project. While I had not covered the topics in my classes at this point it was extremely beneficial to be able to use my knowledge that I had developed through the research to apply it in my classes. The problems would only escalate in difficulty, however, I was still eager to work on them, because Computer Science is my passion, and this is the way I will have the opportunity to make an impact on the world."

d) Student Work/Class Commitments

None.

e) Student(s) Resume/CV (can paste here or upload separately to SASOffice@lasalle.edu)

Please see Attachment C.

15. Separate Endorsement Letter from Department Chair or Graduate Director emailed to SASOffice@lasalle.edu

Dr. Jonathan Knappenberger will send the letter.

Attachment A: A Re-Visit of Service Mapping with Node Re-Visitation in Network Virtualization

I. Service Mapping Problem in Network Virtualization

What is Virtualization? In recent decades, the IT industry is experiencing an era of "*virtualization of everything*": resources including infrastructure, server (node), bandwidth (link), network, and network function are all virtualized. The essence of virtualization is the abstraction and sharing of physical resources among multiple users while providing an illusion of sole ownership of resources for each user (as an analogy, with proper scheduling, two Taxi drivers share one car without conflictions as if each is the sole owner). For instance, as shown in Fig. 1, the physical resources of a server are abstracted and sliced through a virtualization software (i.e., hypervisor) to supply multiple virtual machines (VMs). Each user can occupy one VM in the server without the awareness of VMs of other users. Virtualization allows the agile deployment (i.e, a user can obtain a running VM in minutes with no functional differences from a physical server that takes weeks to build), and elastic usage (i.e., a user can add/remove VMs based on run-time needs such as seasonal traffic fluctuation) of physical resources, which is the enabler of the *Amazon EC2* business model [1].

What is Network Virtualization (NV)? Network virtualization extends above idea one step further: not only servers are virtualized, but also bandwidth resources on links (that connect servers in the physical network) are virtualized [2]. Bandwidth virtualization implies that each user can obtain a sliced and isolated portion of the bandwidth resources to interconnect the VMs of his or her own, thus resulting an illusion of a *network* of sole ownership. Correspondingly, in network virtualization, a user typically expresses the demand as a virtual network request (VNR) that consists of virtual nodes (that represent the needed VMs) and virtual links (that represent the required bandwidth between VMs). For instance, in Fig. 2, the VNR consists of four virtual nodes (each asks for 100 units of computing resources), and four virtual links (each asks for 200 units of bandwidth resources).

What is the Service Mapping Problem in NV? Note that the most important enabling problem in network virtualization is the *Service Mapping* problem: given a VNR, where and how can we instantiate the VMs and the bandwidth slices over the physical network? This mapping problem is traditionally known as the virtual network embedding (VNE) problem [2], and includes two components: *node assignment* that determines physical servers for creating the VMs; and *link mapping* that allocates the bandwidth slices along paths to connect the VMs. The VNE problem is proven to be NP-Complete, which is a class of problems in Computer Science that are extremely hard to solve efficiently [3].

II. Node Re-Visitation (NR) in Network Virtualization

What is NR? In the literature, the service mapping problem is studied assuming that each VM of a VNR is created on a different physical server. This is illustrated in Fig. 3(a), for the four-node VNR in Fig. 2(a), each node (i.e., A to D) has to reside in a different physical server (i.e., 1 to 4, respectively). This case is referred to as *service mapping without re-visitation*. In contrast, node re-visitation (NR) allows the hosting of multiple VMs of the same VNR on the same physical server. Even though NR is rarely studied in the literature, it is inherently supported by the nature of virtualization technologies (e.g., multiple Amazon EC2 instances of the same or different tenants can co-reside in the same physical machine [1]). Co-located VMs of the same physical server can also communicate (via the virtual switch as indicated by the red line in Fig. 1). In this work, we examine the impact of **node re-visitation** and study the service mapping problem with node re-visitation.

What are the Benefits of NR? Figure 3(b) presents the mapping of the same VNR in Fig. 2(a) when node re-visitation is adopted. In this case, as virtual node A and B (and virtual node C and D) co-reside in the same physical server, only two physical servers are needed (i.e., 1 and 3). Also, the virtual link of A-B (and C-D) can be implemented via *fast* in-memory communication through the virtual switch (without consuming bandwidth resources). Typically, the benefits of node re-visitation include: first, compared to the communication through network bandwidth, the in-memory communication are much faster; second, the in-memory communication can be considered as possessing unlimited amount of bandwidth, thus node re-visitation leads to the savings of network bandwidth as well; third, compared to the mapping without node re-visitation, service mapping with node re-visitation has lower blocking ratio of VNRs due to the reduced bandwidth consumption and increased number of candidate physical servers for each virtual node.

Node Re-Visitation in the Literature: The only literature work that has considered node re-visitation is [4]. As node re-visitation implies that multiple virtual nodes map to the same physical server, the authors of [4] studied node re-visitation in the form of *node pre-clustering* [4]. In node pre-clustering, virtual nodes of a given VNR are grouped as a single clustered virtual node before service mapping. For instance, for the virtual network request in Fig. 2(a), the pre-clustering may group the four nodes into two cluster nodes (i.e., X and Y) as shown in Fig. 2(b). Conceptually, the authors view virtual node A and B (or node C and D) as a new virtual node with a combined computing resource requirement of 200. In addition, the bandwidth requirement between the two clustered nodes is also aggregated and increased to 400. Note that there is a critical issue when approaching node re-visitation in this form of *pre-clustering*: as this pre-clustering has no knowledge about the resource distribution of the physical network, the new VNR in Fig. 2(b) is more likely be rejected in the forthcoming service mapping due to the increased requirements on computing and bandwidth resources. For instance, if the physical network has no servers with at least 200 units of computing resources, then the new VNR will be rejected (while the original VNR in Fig. 2(a) may be accommodated). We conclude that it is un-desirable to predetermine the node re-visitation in the form of pre-clustering virtual nodes *before* service mapping.

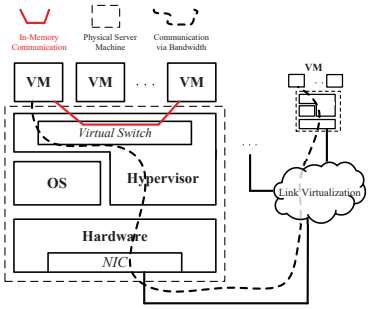

Fig. 1. NV

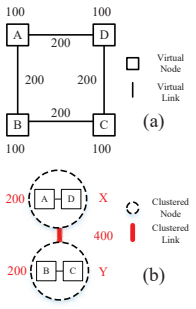

Fig. 2. VNR

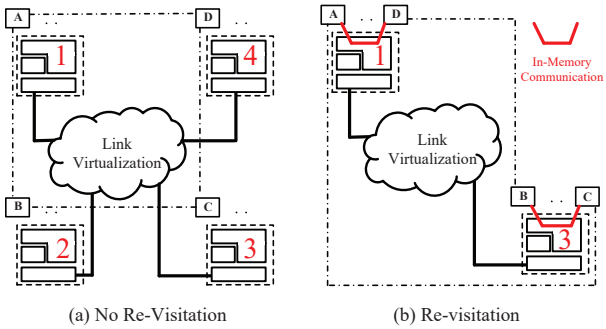

Fig. 3. NR

III. Plan of Study in Our Project

Note that above examples appear to be simple only for the ease of reading. In reality, the service mapping problem with node re-visitation can be very challenging. Given the issue in considering node re-visitation ahead of service mapping, we re-visit node re-visitation and propose to incorporate the consideration of node re-visitation *in the process of* service mapping. Our first step in this project is to prove the NP-Completeness of this problem, and our preliminary results are positive in this direction. Our plan, different from the research in [4], includes the following tasks: formally analyze the underlying technologies of node re-visitation and comprehensively study its impact to service mapping; formally define the service mapping with node re-visitation (SMNR) problem, and develop path-based and link-based Integer Linear Programming (ILP) models to the SMNR problem; resolve the ILP models with a state-of-the-art ILP solver software - *IBM CPLEX* to find an optimal solution. Overall, we expect the findings in this project will be the first comprehensive solution to the SMNR problem, which can shed lights on researches of related topics in network virtualization.

References

[1] "AWS," https://aws.amazon.com/ec2/.
[2] Y. Wang, Q. Hu, and X. Cao, "A branch-and-price framework for optimal virtual network embedding," *Comput. Netw.*, vol. 94, no. C, pp. 318–326, Jan. 2016.
[3] L. Gong, H. Jiang, Y. Wang, and Z. Zhu, "Novel location-constrained virtual network embedding lc-vne algorithms towards integrated node and link mapping," *IEEE/ACM Transactions on Networking*, vol. 24, no. 6, pp. 3648–3661, December 2016.
[4] C. Fuerst, S. Schmid, and A. Feldmann, "Virtual network embedding with collocation: Benefits and limitations of pre-clustering," in *2013 IEEE 2nd International Conference on Cloud Networking (CloudNet)*, Nov 2013, pp. 91–98.

Attachment B

LA SALLE UNIVERSITY
Faculty Curriculum Vitae

Name

Yang Wang

Current Rank

Associate Professor

Department/Program

Mathematics and Computer Science

Education (Include Institution; date of graduation; concentrations)

- **Ph.D. in Computer Science** — June 2012
  Georgia State University — Atlanta, GA
- **M.S. in Computer Science** — April 2011
  Georgia State University — Atlanta, GA
- **M.E. in Computer Science and Technology** — April 2007
  Beijing University of Posts and Telecommunications — Beijing, China
- **B.E. in Computer Science and Technology** — June 2004
  Anhui Normal University — Wuhu, China

Employment (list most-recent first)

- **Associate Professor** — *La Salle University*
  June 2019 – Present
- **Assistant Professor** — *La Salle University*
  August 2013 – June 2019
- **Senior Cloud/Integration/QA Engineer** — *Internap Network Services Corp.*
  February 2012 – August 2013
- ***Senior Network Research Engineer*** — *FutureWei Technologies*
  September 2011 – January 2012
- ***Instructor*** — *Georgia State University*
  October 2008 – August 2012
- ***Development Manager*** — *JAC Software Corporation*
  March 2007 – July 2007

Courses taught at La Salle University

(In total, 8 different courses in 25 sections)

- Fall 2019:
  CSIT 220 Data Communications
  CSIT 320 LANs and Network Administration
  CSIT 422 Information Security

- Spring 2019:
  CSIT 220 Data Communications
  CSC 230 Programming Concepts and User Interfaces
  CSIT 320 LANs and Network Administration
  CSIT 422 Information Security (Independent Study)

- Fall 2018:
  CSIT 220 Data Communications
  CSC 230 Programming Concepts and User Interfaces
  CSC 290 Introduction to Data Structures and Algorithms (Lab)

- Spring 2018:
  CSC 240 Database Management Systems (two sections)
  CSIT 422 Information Security

- Fall 2017:
  CSC 240 Database Management Systems
  CSIT 320 LANs and Network Administration (two sections)

- Spring 2017:
  CSC 151 Introduction to Computing using Packages
  CSIT 220 Data Communications (two sections)

- Fall 2016:
  CSC 290 Introduction to Data Structures and Algorithms
  CSIT 422 Information Security

- Spring 2016:
  CSC 280 Object Programming
  CSIT 422 Information Security

- Fall 2015:
  CSC 290 Introduction to Data Structures and Algorithms
  CSIT 320 LANs and Network Administration (two sections)

- Spring 2015:
  CSIT 220 Data Communications
  CSC 280 Object Programming

- Fall 2014:
  CSIT 220 Data Communications (two sections)
  CSIT 422 Information Security

- Spring 2014:
  CSC 151 Introduction to Computing using Packages
  CSIT 220 Data Communications
  CSIT 320 LANs and Network Administration

- Fall 2013:
  CSC 151 Introduction to Computing using Packages
  CSIT 220 Data Communications
  CSIT 320 LANs and Network Administration

Publications *during* the time period under consideration

Book Chapters (if applicable)

- Q. Duan, **Y. Wang**, A. Bernstein, and M. Toy, "*Virtualization in Networking,* " Chapter 3 in the book *Virtualized Software-Defined Networks and Services*, Artech House, Norwood, p. 95-167, MA (2017)
- Z, Trabelsi, M. McCoey, and **Y. Wang**, "*Teaching Offensive Lab Skills: How to Make It Worth the Risk?*" Chapter 11 in the book *Handbook of Research on Diverse Teaching Strategies for the Technology-Rich Classroom?, IGI Global*, p. 138-152, PA (2019)

Under Review

- **Y. Wang,** and Jabree Flor**,** "*Virtual Network Embedding with the Minimum Embedding Cost: a Cutting Plane Approach,*" submitted to IEEE Transactions on Networking, (2020)

Published Peer-Reviewed Journal Articles

- **Y. Wang (Corresponding Author),** T. Blum and P. McCoey**,** "*Teaching Database for Freshmen: A Two-Thread Model,*" to appear in Journal of Computing Sciences in Colleges (2020)
- **Y. Wang (Corresponding Author),** Z. McNulty, H. Nguyen, "*Network Virtualization in Spectrum Sliced Elastic Optical Path Networks,*" in the IEEE/OSA Journal of Lightwave Technology, Vol. 35, Issue 10, p. 1962-1970 (2017)
- **Y. Wang (Corresponding Author),** P. Chau and F. Chen**,** "*Towards a Secured Network Virtualization,*" in the Elsevier Journal of Computer Networks, Vol. 104, p. 55-65 (2016)
- **Y. Wang (Corresponding Author)**, Q. Hu, and X. Cao, "*A Branch-and-price Framework for Optimal Virtual Network Embedding,*" in the Elsevier Journal of Computer Networks, Vol. 94, p. 318-326 (2016)

Other Articles or Publications (please indicate status)

Peer-reviewed Conference Proceedings Paper (Accepted):

- M. Jalalitabar**. Y. Wang,** X. Cao**,** "*Branch-Aware Service Function Placement and Routing in Network Function Virtualization,*" in the Proceedings of the IEEE Conference on Network Function Virtualization and Software Defined Networks (NFV-SDN), p.15-20, (2019)
- M. Jalalitabar**. Y. Wang,** X. Cao**,** "*Branch-Awareness in Service Function Graph Design and Embedding,*" to appear in the Proceedings of the IEEE Sarnoff Symposium (2019)

Peer-reviewed Conference Proceedings Papers (Published):

- **Y. Wang,** H. Nguyen and C. Li**,** "*Resolving Routing and Spectrum Allocation with Optimal Revenue Problem in Spectrum-Sliced Elastic Optical Path Networks,*" in the Proceedings of the 39th IEEE Sarnoff Symposium (2018), p.1-5 (2018)
- **Y. Wang,** P. McCoey and H. Zou**,** "*Developing an Undergraduate Course Curriculum on Information Security,*" to appear in the Proceedings of the 19th ACM Conference on SIG-Information Technology Education (ACM-SIGITE), p. 66-71 (2018)
- **Y. Wang,** H. Nguyen and C. Li**,** "*On the RSA Problem in SLICE Networks: A Novel Relaxation and Decomposition Approach,*" in the Proceedings of the IEEE International Conference on Computer Communications and Networks (ICCCN), p. 1-5 (2018)
- **Y. Wang,** T. Blum and P. McCoey**,** "*Teaching Network Administration in the Era of Virtualization: A Layered Approach,*" in the Proceedings of the 18th Annual Conference on Information Technology Education (ACM-SIGITE), p. 97-102 (2017)
- **Y. Wang**, "*Network Virtualization over SLICE Networks,*" in the Proceedings of the 36th IEEE Sarnoff Symposium, p. 145-149 (2015)
- **Y. Wang**, P. Chau and F. Chen, "*A Framework for Security-Aware Virtual Network Embedding,*" in the Proceedings of the IEEE International Conference on Computer Communications and Networks (ICCCN), p. 1-7 (2015)
- **Y. Wang**, T. Blum and M. McCoey, "*Teaching a Networking Class for Freshmen: Course Design and Lessons Learned,*" in the Proceedings of the 15th ACM Conference on SIG-Information Technology Education (SIGITE), p. 9-14 (2014)
- P. Chau, **Y. Wang**, "*Security-Awareness in Network Virtualization: A Classified Overview,*" in the Proceedings of the IEEE International Conference on Mobile Ad-hoc and Sensor Systems (MASS), p. 545-550 (2014)
- Q. Hu, **Y. Wang**, and X. Cao, "*Virtual Network Embedding: An Optimal Decomposition Approach,*" in the Proceedings of the IEEE International Conference on Computer Communications and Networks (ICCCN), p. 1-6 (2014)
- **Y. Wang**, Q. Hu, and X. Cao, "*Connectivity as a Service: Towards Optical-based Network Virtualization,*" in the Proceedings of the International Conference on Computing, Networking and Communications, p. 264-268 (2014)
- S. Shakya, **Y. Wang**, X. Cao, Z. Ye, and C. Qiao, "*Minimize Sub-carrier Reallocation in Elastic Optical Networks using Traffic Prediction,*" in the Proceedings of the IEEE Global Communications Conference (GLOBECOM), p. 2374-2379 (2013)

Publications *prior* to the time period under consideration

Book Chapters (if applicable)

- **Y. Wang**, V. Anand, and X. Cao, "*Waveband Switching: A Scalable and Cost Efficient Solution for the Internet Backbone*," Chapter 10 of book: *Solutions for Sustaining Scalability in Internet Growth*, p. 195-217, IGI Global (2013)

Peer-Reviewed Journal Articles

- Q. Hu, **Y. Wang**, and X. Cao, "*Survivable Network Virtualization for Single Facility Node Failure: a Network Flow Perspective*," in the Elsevier Journal of Optical Switching and Networking, Vol. 10, Issue 4, p. 406-415 (2013)
- **Y. Wang (Corresponding Author)**, X. Cao, A. Caciula, and Q. Hu, "*Batch Scheduling in Optical Networks*," in the IEEE/OSA Journal of Optical Communications and Networking, Vol. 5, Issue 2, p. 116-126 (2013)
- **Y. Wang (Corresponding Author)**, X. Cao, "*Multi-granular Optical Switching: A Classified Overview for the Past and Future*," in the IEEE Communications Surveys & Tutorials, Vol. 14, Issue 3, p. 698-713 (2012)
- **Y. Wang (Corresponding Author)**, X. Cao, Q. Hu, and Y. Pan, "*Towards Elastic and Fine-granular Bandwidth Allocation in Spectrum-sliced Optical Networks*," in the IEEE/OSA Journal of Optical Communications and Networking, Vol. 4, Issue 11, p. 906-917 (2012)
- **Y. Wang (Corresponding Author)**, X. Cao, "*A Study on the Dynamic Waveband Switching in Multi-granular Optical Networks*," in the IEEE/OSA Journal of Optical Communications and Networking, Vol. 3, No. 5, p. 390-398 (2011)
- **Y. Wang (Corresponding Author)**, X. Cao, "*Multi-granular Waveband Assignment and Protection in WDM Networks*," in the IEEE/OSA Journal of Lightwave Technology, Vol. 28, Issue 23, p. 2004-2013 (2010)

Other Articles or Publications

Peer-reviewed Conference Proceedings Papers (Published):

- H. Xie, **Y. Wang**, and G. Shi, "*Scale Content Centric Networks via Reactive Routing*," in the Proceedings of the IEEE International Conference on Communications (ICC), p. 3530-3535 (2013)
- Q. Hu, **Y. Wang**, and X. Cao, "*Towards Survivable Network Virtualization*," in the Proceedings of the IEEE International Conference on Communications (ICC), p. 2246-2250 (2013)
- Q. Hu**, Y. Wang,** and X. Cao**,** "*Resolve the Virtual Network Embedding Problem: A Column Generation Approach*," in the Proceedings of the IEEE International Conference on Computer Communications (INFOCOM), p. 410-414 (2013)
- **Y. Wang**, X. Cao, and C. Qiao, "*Minimize Subcarrier Re-allocation Overhead in SLICE Networks with Dynamic Traffic*," in the Proceedings of the Optical Fiber Communication Conference and Exposition and the National Fiber Optic Engineers Conference (OFC/NFOEC), p. 1-3 (2013)
- **Y. Wang**, X. Cao, A. Caciula, and Q. Hu, "*Batch Scheduling in Optical Burst Networks with Feedback/Feedforward FDLs*," in the Proceedings of the IEEE Global Communications Conference (GLOBECOM), p. 2965-2970 (2012)
- Q. Hu**, Y. Wang,** and X. Cao**,** "*Location-constrained Survivable Network Virtualization*," in the Proceedings of the 35th IEEE Sarnoff Symposium, p. 1-5 (2012)

- **Y. Wang**, X. Cao, A. Caciula, and Q. Hu, "*On-line Batch Scheduling in Distributed Optical Networks*," in the Proceedings of the IEEE 26th International Parallel and Distributed Processing Symposium Workshops & PhD Forum (IPDPSW), p. 886-893 (2012)
- **Y. Wang**, X. Cao, "*Wavelength Retuning in Multi-granular Optical Networks*," in the Proceedings of the 20th International Conference on Computer Communications and Networks (ICCCN), p. 1-6 (2011)
- **Y. Wang**, X. Cao, and Q. Hu, "*Routing and Spectrum Allocation in SLICE Networks*," in the Proceedings of the IEEE International Conference on Communications (ICC), p. 1-5 (2011)
- **Y. Wang**, X. Cao, and Y. Pan, "*A Study of the Routing and Spectrum Allocation in Spectrum-sliced Elastic Optical Path Networks*," in the Proceedings of the IEEE International Conference on Computer Communications (INFOCOM), p. 1503-1511 (2011)
- **Y. Wang**, X. Cao, "*Distributive Waveband Assignment in Multi-granular Optical Networks*," in the Proceedings of the 2010 IEEE International Symposium on Parallel & Distributed Processing (IPDPS), p. 1-9 (2010)
- **Y. Wang**, X. Cao, "*Adaptive Waveband Switching in WDM Networks*," in the Proceedings of the Optical Fiber Communication Conference and Exposition and the National Fiber Optic Engineers Conference (OFC/NFOEC), p. 1-3 (2010)
- **Y. Wang,** X. Cao, "*Non-uniform Waveband Switching in Multi-granular Optical Networks*," in the Proceedings of the IEEE Global Communications Conference (GLOBECOM), p. 1-6 (2009)
- **Y. Wang,** X. Cao, "*A New Hierarchical Waveband Assignment Algorithm in Multi-granular Optical Networks*," in the Proceedings of the 18th International Conference on Computer Communications and Networks (ICCCN), p. 1-6 (2009)
- X. Cao, **Y. Wang**, A. Caciula, and Yichuan Wang, "*Developing a Multifunctional Network Laboratory for Teaching and Research*," in the Proceedings of the 10th ACM Conference on SIG-Information Technology Education, p. 155-160 (2009)
- **Y. Wang**, X. Cao, "*Band-segment Protection in Multi-granular Optical Networks*," in the Proceedings of the IEEE Sarnoff Symposium, p. 1-5 (2009)

Papers delivered *during* the time period under consideration

Peer-Reviewed

- "*On the RSA Problem in SLICE Networks: A Novel Relaxation and Decomposition Approach*," at the IEEE International Conference on Computer Communications and Networks (ICCCN), August 2018
- "*Network Virtualization over SLICE Networks*," at the 36th IEEE Sarnoff Symposium, September 2015
- "*A Framework for Security-Aware Virtual Network Embedding*," at the IEEE International Conference on Computer Communications and Networks (ICCCN), August 2015

Poster Presentations (Indicate whether peer-reviewed)

- "*OVNE: Enabling Network Virtualization over an Optical Substrate*," in the Poster Session of the 23th Wireless and Optical Communications Conference, May 2014 (peer-reviewed) (with my students P. Chau and M. Mazzucca)

Other Presentations

- "*Introduction to Undergraduate Research at La Salle*," Talk at A&S First Year Faculty Meeting, November 2015
- "*Introduction to Undergraduate Research at La Salle*," Talk at A&S First Year Faculty Meeting, November 2014

Papers delivered ***prior* to the time period under consideration**

Peer-Reviewed

- "*Wavelength Retuning in Multi-granular Optical Networks*," at the 20th International Conference on Computer Communications and Networks (ICCCN), 2011
- "*Routing and Spectrum Allocation in SLICE Networks*," at the IEEE International Conference on Communications (ICC), 2011
- "*A Study of the Routing and Spectrum Allocation in Spectrum-sliced Elastic Optical Path Networks*," at the IEEE International Conference on Computer Communications (INFOCOM), 2011
- "*Distributive Waveband Assignment in Multi-granular Optical Networks*," at the 2010 IEEE International Symposium on Parallel & Distributed Processing (IPDPS), 2010
- "*Developing a Multifunctional Network Laboratory for Teaching and Research*," at the 10th ACM Conference on SIG-Information Technology Education, 2009
- "*An Energy-efficient Disjoint Path Routing Approach for Wireless Ad-hoc Networks*," at the ISCA International Conference on Parallel and Distributed Computing (and Communications) Systems (PDCCS), 2009
- "*Tree-based Burst Aggregation in Optical Burst Switching Networks*," at the ISCA International Conference on Parallel and Distributed Computing (and Communications) Systems (PDCCS), 2009
- "*Band-segment Protection in Multi-granular Optical Networks*," at the IEEE Sarnoff Symposium, 2009

Poster Presentations (Indicate whether peer-reviewed)

- "*Adaptive Waveband Switching in WDM Networks*," in the Poster Session of the Optical Fiber Communication Conference and Exposition and the National Fiber Optic Engineers Conference (OFC/NFOEC), 2010 (peer-reviewed)

Awards / Honors Bestowed

- *TestOut.Com* Grant for Ethical Hacking Course Development ($4296), 2020

- La Salle University A&S Summer Research Grant ($5000): *Branching-Aware Service*

Function Placement and Routing in Network Function Virtualization, 2019

- NSF Travel Grant to BRIDGES workshop at Temple University ($370), 2018
- *Exemplary Reviewer* Award for IEEE Communication Letters Journal, IEEE Communications Society, 2017
- La Salle University A&S Summer Research Grant ($6000), *Virtual Function Placement and Chaining in Network Function Virtualization*, 2017
- Army Research Office (ARO) Junior Faculty Travel Grant to IEEE CNS Conference ($500), 2016
- La Salle University A&S Summer Research Grant ($5000): *Towards an SLICE-enabled Virtualized Internet*, 2016
- Amazon AWS Education Grant Award ($4000), *Outsourcing the Management while Maintaining the Control: Teaching Network Administration in the Era of Cloud Computing*, 2015 – 2016
- La Salle University A&S Summer Research Grant ($6500), *Optimal, Efficient, and Secure Network Virtualization: Towards an Agile Future Internet*, 2014
- IEEE Faculty Travel Grant to MASS Conference ($400), 2014
- *Exemplary Reviewer* Award for IEEE Communication Letters Journal, IEEE Communications Society, 2014

Professional Activities / Memberships

- Member: IEEE
- Technical Program Committee Member:
  - IEEE 5G World Forum 2018, 2019, 2020
  - IEEE Global Communications Conference (GLOBECOM) 2016, 2017, 2018, 2019
  - IEEE International Conference on Communications (ICC) 2019, 2020
  - International Conference on Computing, Networking & Communications (ICNC) 2014, 2015, 2016, 2017, 2018, 2019, 2020
  - IEEE Sarnoff Symposium 2015, 2016, 2017, 2019
  - IEEE Symposium on Computers and Communications (ISCC) 2017, 2018, 2019, 2020
  - IEEE Workshop on Network Services 2019, 2020
  - ACM International Conference on Modeling, Analysis and Simulation of Wireless and Mobile Systems (MSWiM) 2017, 2018, 2019

  - Fourth IEEE International Workshop on Mobile Cloud Computing systems, Management, and Security (MCSMS) 2018
  - IEEE International Broadband and Photonic Conference (IBP) 2015
  - Wireless and Optical Communications Conference (WOCC) 2013
  - International Workshop on Optical Networking (WON) 2013
- Session Chair
  - International Conference on Computer Communications and Networks (ICCCN) 2015
- Publicity Chair
  - IEEE International Conference on Big Data and Cloud Computing (BDCloud) 2016
- Editorial Board Member:
  - International Journal of Green Computing and Sustainability (April 2014 – Present)
  - Journal of Computer Games and Communication (April 2014 – Present)
- Journal Reviewer (73 reviews)
  - IEEE Communications Letters Journal (22 reviews)
  - Journal of Optical Communications & Networking (10 reviews)
  - IEEE Systems Journal (8 reviews)
  - Computer Communications (6 reviews)
  - International Journal of Cloud Computing (4 reviews)
  - Photonic Network Communications (3 reviews)
  - Computer Networks (2 reviews)
  - International Journal of Communication Systems (2 reviews)
  - Annals of Telecommunications (2 reviews)
  - ETRI Journal (2 reviews)
  - IEEE Transactions on Parallel and Distributed Systems (1 review)
  - IEEE Journal on Selected Areas in Communication (1 review)
  - IEEE Transactions on Cloud Computing (1 review)
  - Journal of Computer Games and Communication (1 review)
  - IEEE/ACM Transactions on Networking (1 review)
  - Journal of Computer Science and Technology (1 review)
  - Frontiers of Information Technology & Electronic Engineering (1 review)
  - Journal of Optical Communications (1 review)
  - Microwave and Optical Technology Letters (1 review)
  - Optical Switching and Networking (1 review)
  - IEEE Transactions on Computers (1 review)
  - IEEE JSAC (1 review)

- Conference Reviewer (52 reviews since 2013)
  - ACM SIGITE 2018 (6 reviews), 2019 (4 reviews)
  - IEEE ICC 2020 (2 reviews), 2019 (2 reviews)
  - IEEE GLOBECOM 2014 (2 reviews), 2016 (5 reviews), 2017 (2 reviews), 2018 (2 reviews)
  - ICNC 2014 (2 reviews), 2015 (1 review), 2016 (1 review), 2017 (2 reviews), 2018 (1 review)

- IEEE ISCC 2017 (2 reviews), 2018 (3 reviews)
- IEEE Sarnoff Symposium 2016 (2 reviews), 2017 (2 reviews)
- MSWiM 2017 (1 review), 2018 (2 reviews)
- IEEE IBP 2015 (3 reviews)
- IFIP NOMS 2016 (2 reviews)
- MCSMS 2018 (2 reviews)
- IEEE INFOCOM 2016 (1 review)

University/School/Program/Department Service

- Department/Program
  - Assessment Liaison for Information Technology Program (2016 – Present)
  - CIS/ITL Graduate Program Capstone Reviewer for
    - Ike Onyiliogwu: *Money Laundering by Politically Exposed Persons in Nigeria: Consequences and Combative Measures* (Summer 2018)
    - Cindy Casey and Ronald Bishof: *TV White Space: Super Wi-Fi or Covert Communication Network for Terrorists?* (Fall 2017)
    - Lauren Storbrauck: *Mobile Device Use: Increasing Privacy and Security Awareness in Healthcare* (Spring 2015)
    - David Solomon and Brian Pillar: *Voice Recognition and Mobility in the Legal Industry* (Fall 2014)
    - Shweta Somalwar and Loc Nguyen: *Leveraging the Wireless and Device Explosion to Meet the Increasing Mobile Usage Demands* (Fall 2013)
  - CIS/ITL Graduate Program Capstone Advisor for
    - Adam Gill and William Burch: *Privacy, Security, and Trust with IoT and the Cloud* (Summer 2019)
    - Ashley Tarloski: *Data Backup and Recovery Solutions for LUNA University* (Spring 2016)
  - Advisor for Undergraduate Students (more than 20 students in total) (2014 – Present)
  - Advisor for Honors Project
    - Zachary McNulty: *Approximating NP-Complete Problems using Integer Linear Programming and CPLEX* (Fall 2017)
  - Advisor for Undergraduate Research
    - Jabree Flor (Summer 2019)
    - Hung Nguyen (Summer 2017)
    - Zachary McNulty (Summer 2016)
    - Michael Mazzucca (Summer 2014)
    - Phanvu Chau (Summer 2014)
  - Department Representative at Academic Awards Luncheon
    - For Phanvu Chau (Fall 2015)
    - For John McComas (Fall 2014)
- School
  - Arts & Sciences Assessment Committee (Fall 2017 – Present)
  - Open House, 09/21/2019, 02/09/2019, 10/28/2017, 10/22/2016, 11/21/2015
  - Blue and Gold Day, 04/02/2016

- Invited Speaker at A&S First Year Faculty Meeting on Undergraduate Research, November 2015
- Invited Speaker at A&S First Year Faculty Meeting on Undergraduate Research, November 2014

- University
  - Academic Technology Committee 2016 – 2019
  - Asian-American Faculty Group 2016 – Present
  - Student Award Selection Committee 2016
  - Student Affairs Committee 2014 – 2016

Other Pertinent Information

- Completed Collaborations Online Plus Training on February 24, 2015

Date Printed: 02/16/2020

Jabree Flor

Contact: florj1@student.lasalle.edu or (610)-698-0969 Overall GPA: 2.99

Education

Computer Science Major - La Salle University, Philadelphia, Pennsylvania,
Expected Graduation - May 2022
Pottstown High School Graduate - Pottstown, Pennsylvania
Graduation - June 2018

Experience

McDonalds Manager and Operations Technology Professional- *Mcdonalds*, Pottstown, PA
August 2017 - Present

- Trained incoming workers for both service and grill.
- Consistently reaching sales goals while maintaining the food safety,and security guidelines.
- Closed down the restaurant successfully and efficiently in a timely manner.
- Communicates any technology related issues in the store.
- Resolves any technology concerns in a timely manner to keep the store under normal operations.

A&S Summer Student Research Grant in 2019: *Branching-Aware Service Function Placement and Routing in Network Function Virtualization*

- Developed an understanding of the programming language C.
- Furthered background into Network Virtualization.
- Solved several problems through link based and path based solutions.

Vice President - *Autodidact for Haiti*, Philadelphia, PA
April 2019 - October 2019

- Organized meetings to allow the club to successfully reach deadlines.
- Aided the President in maintaining the club's overall goal.
- Raised funds for the club to continue operating under our mission.

Volunteer at Habitat For Humanity ReStore - *Habitat for Humanity ReStore*, Laureldale, PA
June 2016 - August 2016

- Arrived timely to clean and prepare donations for the storefront.
- Assisted customers in loading furniture purchases into their vehicles.
- Unloaded massive donation deliveries to be cleaned and prepared for purchase.

Achievements

- Yang Wang and Jabree Flor, "*Virtual Network Embedding with the Minimum Embedding Cost: a Cutting Plane Approach,*" IEEE Transactions on Networking (under review), (2020)
- Pottsgrove High School Senior Music Award 2018
- First place in Pottsgrove High School Spelling Bee 2018

- Honor Roll held throughout all semesters of High School

Skills

- Mastered Microsoft Office programs (Word, Excel, PowerPoint).
- Comfortable working in both Microsoft Windows 10 and Mac OS X.
- Understanding of several coding languages such as JavaScript, Python, Java, HTML, C, C#, Kotlin etc.
- Built a personal computer; gained a firm understanding of computer hardware.
- Operations Technology Professional certified which allows the opportunity to troubleshoot and communicate technology related issues.
- Through previous summer research, a strong understanding of C and how to work in CPLEX was developed.