

I. Introduction

I. A. BRIEF RESUME

1. Education background (degrees, certificates, etc.):

- Ph.D., Computer Science, North Carolina State University, Raleigh, NC, USA, August 2001.
 - “Virtual Topology Design for Traffic Grooming in WDM Networks”, Advisor: George N Rouskas
- M.Engg System Science and Automation, Indian Institute of Science, Bangalore, India, January 1993.
 - “Extended Back-Propagation Algorithm for Training Multi-Layer Perceptrons”, Advisor: M N Murthy
- B.Engg., Electrical Engineering, Jadavpur University, Kolkata, India, July 1991.
 - “Artificial Neural Networks: A Study of Match Region Non-Convexity”, Advisor: Tapan K Ghoshal

2. Professional experience (employment, sabbaticals, etc.):

- August 2013 – present: Professor, NCSU, Department of Computer Science
- August 2007 – July 2013: Associate Professor, NCSU, Department of Computer Science
- August 2001 – August 2007: Assistant Professor, NCSU, Department of Computer Science
- June 2005 – August 2005: Visiting Researcher at Websphere Technology Institute, IBM
- January 1993 – June 1997: Software Engineer, IBM (Bangalore, India; Sydney, Australia; RTP, NC, USA)

3. Scholarly and creative activities/publications (see CV for details):

Books	Career Total (number)	Since Joining NCSU	2017 Total	Total over moving PTR Period ¹
Authored books	2	2	-	1
Edited books and Proceedings	5	5	-	1
Refereed book chapters	4	4	-	-
Journal special issues	6	6	-	3

Papers, Articles, Patents, Reports, News Interviews ...	Career Total (number)	Since Joining NCSU	2017 Total	Total over moving PTR Period ¹	Submitted
Refereed journal articles	29	28	6	9	1
Refereed conference papers	73	72	1	23	1
Refereed workshop papers	7	7	-	4	-
Refereed posters	2	2	-	-	-
News mentions (external)	5	5	-	2	-

Mentoring and Supervision (see CV for details)	Career Total (number)	Since Joining NCSU	2017 Total	Total over moving PTR Period ¹	In Progress ¹
PhD (chair/co-chair)	11	11	1	5	4
MS (chair/co-chair)	21	21	-	2	1

Talks, Presentations, etc.	Career Total (number)	Since Joining NCSU	2017 Total	Total over moving PTR Period ¹
Other invited talks	3	3	-	1

¹ Last three (3) years for Associate Profs, last five (5) years for Full Profs who have been at NC State for at least the PTR number of years. Faculty who have been at NC State for less than the PTR number of years should enter “Since Joining NCSU” numbers.

Funded Research, Development and Teaching	Career Total (dollars)	Since Joining NCSU	2017 Total (\$)	Total over moving PTR Period ¹ (\$)	Pending (\$)
Contracts and Grants	6591 K	6591 K	-	692 K	-
Gifts (cash)	50 K	50 K	-	-	-
Gifts (in kind)	56 K	56 K	-	-	-
Internal (competitive)	138 K	138 K	-	-	-

Courses taught (put distance Ed and summer courses into separate, additional rows)	Career Total (number)	Since Joining NCSU	2017 Total	Total over moving PTR Period ¹
Regular undergraduate (3 credits, 10 < x < 100 students)	8	8	-	3
Large undergraduate (3 credits, x > 100 students)	2	2	-	-
Regular graduate (3 credits, 10 < x < 100 students)	31	31	3	9
Small graduate (3 credits, x < 10 students, e.g., independent studies, special topics)	10	10	1	4

Courses created and/or revised in a significant way (complete list in CV)	Career Total (number)	Since Joining NCSU	2017 Total	Total over a moving PTR Period ¹
Undergraduate	2	2	-	1
Graduate	9	9	1	5

Other (see CV and/or next page for details)	Career Total (number)	Since Joining NCSU	2017 Total	Total over a moving PTR Period ¹
Creation of Departmental level Labs/Facilities	4	4	1	1
Creation/Direction of University level Facility	2	2	-	1

4. Membership in professional organizations (current, see CV for full list)

- Institution of Electrical and Electronics Engineers (IEEE), and IEEE ComSoc, Member since 2001, Senior Member since 2015
- Association for Computing Machinery (ACM), Member since 2003, Distinguished Member since 2016
- International Federation for Information Processing, Working Group 6.10, Member since 2002

5. Scholarly and professional honors: (selection, see CV for full list)

- Invited to be visiting scientist at IBM Websphere Institute in Summer, 2005

6. Professional service on campus: (current, see CV for full list)

- Member, University Standing Committee on Extension, Engagement, and Economic Development, 2017-18, 2016-17.
- Member, Inaugural University Mentor-Rings program, Spring 2016, subsequently 2016-17, 2017-18.
- Member, Strategic Planning Committee, CSC Dept, 2015-16, 2014-15.
- Member, Graduate Program Oversight Committee, CSC Dept, 2016-17, 2015-16, 2014-15, 2013-14, 2012-13, 2011-12, 2010-11.
- Chair of the Graduate Admissions Committee, Computer Science Department, 2009-10, 2008-09, 2007-08.

7. Professional service off campus (selection, see CV for complete list):

- TPC Co-Chair, IEEE Sarnoff Symposium, 2017
- TPC Co-Chair, IEEE NFV/SDN 2017
- TPC Co-Chair, IEEE Sarnoff Symposium, 2016

- TPC Chair, International Conference on Design of Reliable Communications Networks, 2015
- Steering committee member, IEEE Advanced Networking and Telecommunications Conference, 2011, 2012, 2013
- Editor, Elsevier Journal of Optical Switching and Networking
- General Chair, IEEE Advanced Networking and Telecommunication System (ANTS) 2010
- Program Chair, Optical Networking Symposium, IEEE Globecom, 2008
- Grant proposal review panelist, US National Science Foundation (2005, 2008, 2012, 2014, 2016)
- Grant proposal review panelist, US Department of Energy (2009)
- Grant proposal reviewer, Canadian Natural Sciences and Engineering Research Council (2011)
- Grant proposal reviewer, US Army Research Office (2012, 2013, 2016)
- Technical Program Committee member and reviewer of numerous high-quality conferences, including IEEE Infocom, ICC, Globecom, ICCCN, ANTS, SECON
- Reviewer for many premium journals, including IEEE/ACM Transactions on Networking, IEEE Journal on Selected Areas in Communications, IEEE Transactions on Computers, IEEE Communications Letters, Elsevier Journal of Optical Switching and Networking, Elsevier Computer Networking

I.B Personal Statement

Over the past 17 years at NCSU, Dr. Rudra Dutta has extended and adapted his research to a wide variety of emerging areas, graduated 11 PhD students, published over 100 papers and articles, three books, and been awarded over \$6 million in external funding. He has created new curriculum, and developed lab facilities and environments, including one university-level facility. He has also engaged in the community in ways beyond teaching and research, through student challenges, mentoring high-school and exchange students, and holding demonstrations of his research. Dr. Dutta's early research was in global performance and resource optimization for optical networks. Since then, he has expanded into network architecture research, wireless and mobile network design, and research infrastructure design – all crucial areas in networking that are gathering increasing attention. The unifying theme in these activities is the architectural challenge of more tightly coupling the network to “real” information: from applications, from other computing entities, from the physical world beyond computing. As solutions to traditional networking challenges become more commoditized, these are the areas the new networking challenges will come from.

Recent and Ongoing Activities of Note

CPS testbed in EB2: Since Spring 2015, Dr. Dutta has been engaged in a project to establish a distributed testbed of small computing devices in EB2. These devices are small form-factor full-fledged Linux computers, but also have a broad range of I/O pins, allowing sensors and actuators to be easily plugged in. This will serve as a distributed facility for the teaching, and possibly also support research, in the area of Cyber-Physical Computing. The facility is reusing the back-end network connectivity previously created in EB2 for the Wisenet research testbed that Drs. Ning and Rhee installed, and that reached end-of-life around 10 years ago. The computing and sensing equipment that is being installed at those locations was acquired by Dr. Dutta on an ETF allocation.

CentMesh Upfit for IoT: The original purpose of the CentMesh facility was to support research and teaching in the area of wireless networks in general, and wireless mesh networking in particular. In the last year or two, there has been a high degree of interest in Internet of Things, and SmartCity oriented research. Dr. Dutta has been engaged in an effort to re-equip CentMesh so that it can serve as the edge cloud and wireless connectivity backbone for a campus IoT testbed. He is working with OIT, Facilities, and Centennial Campus Development personnel to realize this vision.

Seminar Course on “Preparation for academic research”: Over the academic year 2015-16, one of the ongoing discussions among faculty centered on how to improve the early PhD experience in the Computer Science department. A proposition that was advanced was to create a “research seminar” course, that incoming PhD students would be encouraged (or in time, perhaps required) to take in each of their first two semesters. This would directly free them up from one course per semester, while making degree progress without falling below full-time enrollment (this research seminar course would count toward their PhD degree credits). The proposal was viewed favorably by faculty, but it was felt that at least a trial was required before formally creating the process, or requiring first-year Ph.D. students to go through it. Dr. Dutta voluntarily offered such a course in Fall, 2016, as an uncredited overload to his normal teaching load. The results were quite favorable, and a group of faculty members reviewed the experience that students received in that course, during which they dissected papers, criticized them, tried to prepare presentations, posters, and elevator speeches of research topics, etc. Dr. Dutta offered the seminar course again for Fall, 2017, and this time all incoming Ph.D. students were strongly encouraged to take it; 28 out of 33 incoming students did so. Reviews were very favorable, and the department is planning to make this process a permanent one.

Outreach for IoT/SmartCity Research: In Spring, 2017, Dr. Dutta was instrumental in inviting an NSF Program Manager to visit NC State, and review NC State's preparedness for multi-disciplinary research in this emerging area of importance. The NSF PM also gave a talk on the various new funding instruments for this type of research that have been created at NSF. Dr. Dutta scheduled meetings with various NC State faculty whose work was relevant in this area, and the NSF PM commented before departing that he was very favorably impressed with NC State's presence in this area, with which he had previously been less acquainted.

Less Recent Activities

Human aspect of Network Management: Dr. Dutta guided one of his Ph.D. students, Magreth Mushi, in investigation into a hitherto completely unexplored area of network analysis and design – a study of the human process in network administration and management. Much previous work has gone into making the technology for such networks reliable. However, networks have to be administered and managed by human administrators. The process of such administration,

as it becomes increasingly complex, itself poses a challenge to protocols and systems designed to enhance network reliability. Magreth has conducted studies and interviews that expose typical mistakes in this process, which makes the network vulnerable to malicious attacks, or natural failure. Magreth is going beyond the study into an approach where the newly emerging paradigm of Software Defined Networking can be utilized to provide a sanity check on the actions taken by an administrator – this was demonstrated recently at the Global City Teams Challenge Expo in Washington, DC. She went on to model the failures in the human process better, and to define an SDN-based language that abstracts the failure-process processes and thus hides them from human action. Incidentally, Magreth has been a doctoral student at NCSU for three years on a Fulbright scholarship, and was awarded the prestigious Schlumberger scholarship for 2015-16. Publications [J1, 14] provide an outline of this area.

CC-NIE grant: The infrastructure grant that Dr. Dutta spearheaded concluded in 2016. The NCSU network architect, William Brockelsby, closely partnered with Dr. Dutta on this project, and the grant proposal PI was the campus CTO and Vice Chancellor of IT, Marc Hoit. This grant allowed NCSU ComTech to try out an envisioned upgrade of the Campus Access Layer Architecture to allow high-speed network services for researchers, and create high-speed network islands for research labs that need it. In the course of this project, 10 buildings were equipped with the new CALA switches, including EB2, allowing selected research spaces in these buildings to have access to 10 Gbps ports (currently all locations in NCSU have access to at most 1 Gbps ports). This new equipment also enables a future extension into the ability of the campus network to provide virtual “island” networks for physically distributed research facilities using the emerging Software Defined Networking paradigm.

Drones Challenges: In 2013-14, Dr. Dutta and Dr. Mihail Sichitiu (ECE) organized an autonomous drone programming challenge for students. The drones that were the platform of the challenge were fabricated from commodity parts, open-source software, and purpose-built software developed by Drs. Dutta and Sichitiu, and their graduate students. Participating student teams performed a virtual challenge (in simulation) over Fall 2013, and selected teams undertook actual flying challenges in Spring 2014. The final challenge was an all-day event in April, 2014, and was covered by the News and Observer (the major daily newspaper of the Triangle area).

Over 2014-15, Dr. Dutta has been spearheading a new drones challenge. This effort also includes Dr. Mihail Sichitiu of the ECE department, and Dr. Larry Silverberg of the MAE department. The effort has been structured as special topic courses in Fall 2014 and Spring 2015. Students have been challenged on build on the existing expertise gained in the CentMesh project and the First NCSU Centmesh Drones challenge – to design, build, and prove a drone capable of being flown indoors by inexperienced operators, while intelligently avoiding obstacles, sensing heat and flames, and locating survivors in a building on fire: the firefighter’s drone challenge.

Over summer, the best-performing teams from this challenge have been invited to join an effort by Drs. Dutta and Sichitiu to further develop their efforts into a practical platform, testing it with the collaboration of local firefighters, and helping them adopt it if so interested. Ongoing information about the challenge can be found at http://go.ncsu.edu/drones_challenge.

Triangle SDN infrastructure WG: Since late 2013, MCNC, the local high speed network provider for educational and research institutions in NC (including NCSU) has been planning an SDN extension of MCNC’s backbone, that will not only improve service to the client institutions, but also optionally provide SDN services. This requires client institutions to acquire new equipment to take full advantage of the new infrastructure and services that will be put into place. To make sure that the new equipment and network design best serves everybody, a working group has been formed that meets regularly to co-design the new facility. Dr. Dutta is one of the two persons from NCSU serving on this working group (the other is a ComTech engineer).

JUNO Project: One of Dr. Dutta’s currently active research projects has been funded by NSF’s Japan-US Networking Opportunity program, and is a collaborative project with researchers from NICT, Tokyo. The project aims to build a prototype network in which network nodes are capable of both optical circuit and optical packet switching, and a marketplace mechanism to offer pre-groomed service alternatives computed on the basis of current network resource utilization is used to allow the customers and providers to co-optimize network utilization. The prototype will be demonstrated on the GENI and JGN-X facilities.

SDN Labs and Innovation Challenge: Dr. Dutta has created a Software Defined Networking lab in the Computer Science NetLabs to facilitate the teaching of SDN topics, using equipment donated to him, and acquired through research grants, as well as commodity NetLabs servers and open-source software. In Spring 2015, this lab served also to house an outreach activity. Extreme Networks sponsored an SDN Innovation Challenge, in which several research students of Dr. Dutta, and other NCSU students that Dr. Dutta disseminated this through coursework, participated. The

SDN Labs housed the project works of these student groups during the Spring semester, including the equipment provided by Extreme Networks to support the challenge. Two of the NCSU teams were two of the three teams who demonstrated their projects together with Extreme Networks at the First Global City Teams Challenge Expo, organized by NIST, and held in Washington DC in June 2015.

Long-term Activity

Optical Network Design: Dr. Dutta has contributed in many areas of optical networking research, such as virtual topology design, converter placement, traffic grooming, survivability, slack assignment and other areas in resource allocation. Dr. Dutta has performed pioneering work in the field of traffic grooming for optical networks, and is one of the recognized authorities in the world in this area. In particular, “A Survey of Virtual Topology Design Algorithms for Wavelength Routed Networks” and “Traffic Grooming in WDM Networks: Past and Future”, each has over 450 citations (source: Google Scholar) – among the most cited work on these topics ([J27] and [J29] in attached list of publications). Early on in his career, he received substantial funding in this area from NSF. A few years ago, he co-edited (as lead-editor) a definitive book in this area. Other notable publications are [J15, J18, J19, J20, J21, J24, J25, J26, J28, 15, 29, 22, 42, 53, 57-62, 64-66, 69-73].

As the field of networking evolves, focus shifts over time to different areas. While optical network optimization is not the top research concern in the networking research community at this time, it remains an important area. Area experts agree that the field holds critical and exciting future research challenges. As broadband penetration and scope grow, innovative approaches will provide competitive advantages, re-energizing this area. Dr. Dutta has continued to maintain a current presence in this area [see above cited publications] and can be expected to continue contributing significantly in the future.

The recent grant awarded by the JUNO (Japan-US Networking Opportunities) program of NSF, mentioned earlier in this section, exemplifies Dr. Dutta’s ongoing work in optical networking. In this project, he is combining his ChoiceNet architecture (see below) with a novel hybrid packet-circuit optical switch designed by Japanese collaborators in order to prototype an actual on-demand economy-driven dynamically provisioned hybrid optical network.

Network Architecture: In 2005, NSF issued a call for “clean-slate future Internet design” proposals. Dr. Dutta’s was one of the few teams to get funded in the very first cycle of this **Future Internet Design (FIND)** program. This is significant not only for the actual funding, but for having made him a participant in a fresh new re-examination of planetary networking architecture. Dr. Dutta’s SILO project envisioned networking functionality to be provided in fine-grain services in the protocol stack (at end-nodes, and within the network), with separate control interfaces for cross-service tuning and optimization. At special FIND events held by NSF, he collaborated with other FIND teams to inform their research with his, and vice versa.

The project ended after two years, with several publications as well as a working prototype proving the concept of the paradigm, and an REU supplement. Dr. Dutta continued contribution in this area through practical network architectural work (the GENI project, see below), as well as, more recently, a larger multi-university grant from NSF under the umbrella of its new program **Future Internet Architecture (FIA)** – this program has only funded 5 research projects. Dr. Dutta’s project is called ChoiceNet – it asks the question whether fine-grain innovation in networking services can be encouraged by integrating a framework for accountable allocation of the customer’s expenditure, targeted measurement of performance, and selective re-composition of the service needed by the customer based on satisfaction of user expectation. It proposes an initial set of architectural building blocks to achieve these goals, such that they could be integrated in not only the current Internet architecture, but a wide variety of other possible architectures, such as those being proposed by the FIA community. News of this grant was covered by National Public Radio (WUNC) in November, 2011, on the “All Things Considered” program, including quotes from Dr. Dutta and other PIs from NCSU and UNC-CH. Notable recent publications in this area are [J8, J10, J13, 2, 4, 7, 13, 15, 19, 22-24, 29, 31, 48, 52, 54] in the attached list of publications, as well as a book chapter.

Wireless Pervasive Networks: As the number of mobile wireless Internet devices grow, and the range of activities users can accomplish with them broadens, the wireless last-hop and last-few-hops paradigms has to be increasingly viewed as the primary citizen in network access. Mechanisms that operate mostly on endpoints, for example security, have to be re-examined under new considerations such as mobility and energy constraints, and new challenges have to be faced. On the network side, the new paradigms such as mesh networks and vehicular infrastructure have to be examined for service continuity and metrics like performability. Dr. Dutta has worked on complementary lines of research along these two directions. One line of research has articulated the continuity aspects of mesh networks,

contributing understanding of the impact of power control on the throughput and performability, and optimal throughput balanced access of mesh networks and sensor networks. These have been published in highly regarded wireless networking conferences. They have garnered attention in the popular press as well; both Softpedia and ZDNet published articles highlighting Dr. Dutta's paper on centrality-based power control, and Phys.org covered his work on variable channel width assignment. Another line of research has focused on the vulnerability of such networks to jamming, and advanced various diverse path approaches for jamming mitigation, or the vulnerability of such networks to Sybil attacks, and advanced mechanisms to mitigate them. This last one has received Science of Security Label funding from NSA. Note that both are vulnerabilities specific to the wireless domain. The solutions advanced are also examples of tight coupling of information from within and without the network to create solutions, distinct from traditional approaches. More recently, Dr. Dutta has focused on Internet of Things architecture, and airborne networking, as extensions of the area of wireless pervasive networking. Dr. Dutta has co-authored a book with one of his PhD students, Parth Pathak, entitled **Designing for Network and Service Continuity in Wireless Mesh Networks**, published in 2012. Other notable recent publications in this area are [J7, J11, J16, J22, J23, 1, 16, 17, 20, 25-27, 33, 36, 37, 41, 45, 51].

Networking Research Infrastructure: A particularly notable achievement of Dr. Dutta is the **Centennial Wireless Mesh Networks (CentMesh)** project: the architecture, development and implementation of an outdoor, highly programmable, extensible, open testbed to support research and education on the design of wireless mesh networks, as well as IT systems and applications enabled by wireless networks, using open source code built by NCSU students and faculty, and re-using other open source code. This resource will positively impact the research opportunities not just for Dr. Dutta's group, but many other researchers on campus, for many years to come. Please see the "Technological and Managerial Innovation" section of this document for more details of this effort.

The **CC-NIE** grant funded project on upgrading NC State's Campus Access Layer Architecture (mentioned above) is a notable more recent example of Dr. Dutta's work in network research infrastructure, and research in network infrastructure.

A three-year grant awarded by the GENI Project Office supported Dr. Dutta's **GENI-IMF** project, which leverages the fruits of the SILO research project to integrate the capability of reacting to cross-layer optimization information with optical layer measurement capabilities. This project was a collaboration between NCSU, Columbia University, and RENCI (UNC-CH), Dr. Dutta was the lead PI. The project is particularly significant because it integrated the architecture and concepts that his SILO research had previously produced into new work that is actually forming part of the national GENI infrastructure. Please see further discussion of this project in the "External Engagement" section of this document.

This experience with GENI allowed Dr. Dutta to take a leadership role in developing a proposal, jointly with NCSU OIT, in response to the CC-NIE solicitation from NSF. This grant is allowing improving the campus broadband structure in labs and facilities requiring specialized networking services, and apply innovative methods to make it more flexible. Other facets of his activities are related to infrastructure considerations. He was involved as an Associate Technical Director with the **Secure Open Systems Initiative (SOSI)**, made possible by a large grant from Congress processed through the Army Research Office. Dr. Dutta was also one of the two faculty members who developed the technical proposal submitted to ARO for SOSI. In Fall, 2010, his successful proposal for a COE one-time competitive ETF funding opportunity was awarded, allowing a revamp and redesign of the **CSC departmental networking laboratory**. He was also awarded a competitive equipment donation program funded by the GENI Project Office for a **Pronto OpenFlow switch**, worth \$15,000.

General Profile: Dr. Dutta has made contributions in all his roles as researcher and teacher, beyond the specific areas of special initiatives above. He has published over 70 peer-reviewed conference and workshop papers and 29 peer-reviewed journal papers, most of them in premier and highly selective forums. He has obtained substantial external funding; not only from agencies that primarily fund academic research (such as NSF), but industrial and collaborative sources as well. One of these, the large collaborative grant SOSI, accounts for more than \$3M of this funding. The rest of his current and past external funding totals to over \$3.3 M. He has graduated 11 Ph.D. students and 21 MS students, and is currently guiding 4 Ph.D. students.

He has taught essential courses in both undergraduate and graduate arenas and obtained good teaching evaluations. His teaching has been more graduate than undergraduate, but this is a function of his specialization and not his inclination (the department has over 15 regular graduate courses in networking and a specialized Masters in Computer Networking degree program, and only 2 undergraduate electives). He remodeled two undergraduate courses (CSC 401 and CSC453) as well as created several new graduate special topic (all were coded CSC 591 or 791) that cover areas previously not addressed in the curriculum; one of these has become a regular offering in the curriculum (CSC/ECE 772

– Survivable Networks), and another (Software Defined Networks) is likely to soon make that transition. In 2006 and 2007, Dr. Dutta taught CSC 230 (C Programming and Software Tools), a then-new course (these were the second and third administrations) crucial to the department’s teaching strategy.

Dr. Dutta has contributed to the broader community, and has been an organizing committee member and chair/vice-chair, and steering committee member of a number of the premier conferences (including IEEE ANTS which breaks new ground – please see “External Engagement” section), served on review panels at NSF and DoE, and as editor for a leading optical networking journal. Inside the university, he has served on the Undergraduate Curriculum Committee for four years, representing the department at the college level for a semester, and has served on other departmental committees including as chair of the Graduate Admissions committee and as member of the Graduate Oversight committee. Dr. Dutta continues to serve the community in various roles – most recently as Technical Program Committee Co-Chair of both the 2017 IEEE Sarnoff Symposium, and IEEE NFV-SDN Conference.

II. Teaching and Mentoring of Undergraduate and Graduate Students

II. A. Teaching Effectiveness

1. Courses Taught: (figures in parentheses denote number of final grades assigned)

1. CSC 230: Spring 2007 (114), Spring 2006 (107)
2. CSC401: Fall, 2011 (38), Spring 2007 (36), Spring 2004 (53), Fall 2003 (62)
3. CSC453: Spring, 2016 (38), Spring, 2015 (28), Fall, 2013 (18), Fall, 2012 (18)
4. ECE/CSC 570: Fall, 2010 (74), Fall 2009 (66), Fall 2008 (42), Fall 2007 (72), Fall 2006 (74), Fall 2004 (21), Fall 2003 (52), Fall '02 (93), Fall '01 (72)
 - Fall 2009, Fall 2007, Fall 2003 and Fall 2002 figures include students in distance education section of the same courses I concurrently taught in these semesters
5. CSC/ECE 573: Fall, 2016 (58), Fall, 2014 (50), Fall, 2014 (36), Fall, 2012 (52), Fall, 2010 (60), Fall, 2010 (20), Spring 2005 (22), Spring 2003 (19), Spring 2002 (64)
6. CSC 495/591 (Firefighters drones challenge): Spring, 2015 (25), Fall, 2014 (23)
 - Enrollment is total of cross-listed sections with ECE and MAE
 - These CSC 495/591 sections do not count toward teaching load
7. CSC 591 (Implementing Small IoT Systems): Spring 2016 (4)
 - These CSC 495/591 sections do not count toward teaching load
8. CSC 591 (SDN Network Prototyping): Spring 2015 (7)
 - These CSC 495/591 sections do not count toward teaching load
9. CSC591/791/ECE592/792 (IoT: Applications and Systems): Spring 2017 (12)
10. CSC591/791/ECE592/792 (Software-Defined Networks): Spring 2017 (25)
11. CSC/ECE 772: Spring 2009 (5)
12. ECE/CSC 777: Fall, 2013 (19), Fall, 2012 (17)
13. CSC/ECE 778 (old 775): Fall 2011 (10), Fall 2009 (5), Fall 2007 (14), Fall 2006 (14)
14. CSC 791B: Fall 2005 (6), Spring 2005 (11)
15. CSC 791B: Spring 2008 (8), Spring 2007 (14)
16. CSC 801: Fall, 2017 (39)
17. CSC 801: Fall, 2016 (6), Spring 2013 (7), Spring 2012 (4), Spring 2011 (11)
 - These CSC 801 sections do not count toward teaching load, are not included in Brief Resume numbers

2. Peer Evaluation of Teaching (Summary):

Spring, 2017, CSC/ECE-591/791/592/792 (IoT Applications and Systems) (conducted by Drs. Munindar Singh and Kemafor Ogan): The peer evaluators noted that the course addresses an emerging area, and is timely. They found that the organization of the web page through which material was made available to the students, as well as the lectures, were well organized and designed to add value to the students' experience. They particularly noted that students remained engaged throughout the lecture, although it was three hours long, and concluded that "Professor Dutta is an effective teacher for an important new course in our graduate curriculum."

Fall, 2012, CSC-453 (conducted by Drs. George Rouskas and Khaled Harfoush): The peer evaluators were uniformly approving of the teaching. They noted that "Dr. Dutta used a projector and slides to present class material. The slides and write-up were structured well and were easy to read. Dr. Dutta's spoken explanations were clear and easy to understand. The slides covered the main points of the lecture, and specific details were discussed verbally. Dr. Dutta made references to other courses and historical information to help students form mental connections. He made every effort to ensure the students properly understood the lecture material, and frequently asked questions to ensure that students were engaged. The result was a stimulating and relaxed learning environment that offered students a combination of visual material and detailed discussion." The evaluators concluded by remarking that they found the offering to be a "well-designed, relevant and challenging class."

Fall, 2008, CSC-570 (conducted by Drs. Christopher Healey and Vincent Freeh): The peer evaluators reported that all instructional tools and materials for the course were appropriate, and were uniformly approving. They noted that “Dr. Dutta made extra effort to provide supplemental information on the web site, including clear definitions of course policies, previous tests, helpful links, and video versions of lectures”, and concluded by saying that “In summary, Dr. Dutta is knowledgeable on the subject matter, projected his enthusiasm for it, and effectively delivered his expertise to the students.”

Spring, 2006, CSC-230 (conducted by Drs. Douglas Reeves and Matthias Stallmann): The peer evaluators reported that materials for the course were appropriate, the distribution through the course website was effective, and the course was informative and interactive. They commented that “We find the course materials for CSC230 as taught by Dr. Dutta to be suitable for the class, at an appropriate level, and carefully prepared.” They also provided some constructive advice about addressing the highly heterogeneous level of incoming students’ prior knowledge of C (a challenge in this course faced by all instructors), which will be incorporated in the next administration of the course in Spring, 2007.

Spring, 2005, CSC-573 (conducted by Drs. Edward Davis and Khaled Harfoush): The peer evaluators reported that: “Dr. Dutta is clearly knowledgeable in the subject. He is also able to deliver this knowledge in an effective way.” They praised the preparation of the lecture and the high quality of slides and course web site, and the instructor’s friendly, direct approach with the students. They suggested the instructor try to draw out the students more and have a more interactive class.

Fall, 2004, CSC-570 (conducted by Drs. Injong Rhee and Matthias Stallmann): The peer evaluators reported that overall, they found Dr. Dutta a good teacher. They noted that all class related materials were easily accessible on the web, the class started on time, the class was very interactive, and students seemed to like the class. The lecture materials were highly relevant to the course. The peer evaluators supplied some easily implementable ideas, such as issuing a 5-minute break in the middle of long classes for increased productivity. The full report is on file at the department.

Fall, 2003, CSC-570 (conducted by Drs. Douglas Reeves and David Thuente): The peer evaluators reported that in summary, Dr. Dutta is a well-prepared, conscientious, and talented teacher. They drew attention to some interpersonal aspects of teaching that could be improved, notably starting the lecture less abruptly and with more friendly interaction with the students. (These suggestions have been used to improve in these areas since then.) The evaluators also noted that both the lecture slides and lecture delivery were clear and precise.

II. B. Instructional Development

CSC 453 – Software for Wireless Sensor Systems: This course was created a few years ago by Dr. Robert Fornaro and taught by him several times. In Fall, 2012, I took over as primary (and since then only) teacher of this course, and thoroughly revising it. It is now effectively an introduction to IoT and Cyber-Physical Systems. As the course changed over a couple of years, there was a mismatch of expectations for enrolled students in the previous two years, leading to bad evaluations and low enrollment. However, now that the course has stabilized, this should improve – in Spring 2016, the course capacity was doubled to 40, and 38 students finished the course.

CSC 401 – Data and Computer Communication Networks: Revamped the contents of this course, and taught it in Fall, 2003 and Spring, 2004. In the preceding few semesters, this course had not been taught by any full-time faculty, but by adjunct faculty members instead. The contents of the course were consequently not contemporary at the time I took over this course. Currently I serve as course coordinator for this course. It is the first of the only two networking courses in the CSC undergraduate curriculum.

ECE/CSC 570 – Computer Networks: This is a networking course cross-listed jointly with the ECE department, for which I currently serve as CSC department contact, and as the main CSC instructor. Recently this course was revised completely and new material created, a new CAF was also filed. Although the course coordinator for this course (Dr.

Mihail Sichitiu) is an ECE faculty member who filed this CAF, I was significantly involved in the effort to revamp this course and develop new material.

CSC 791 B – Special Topic on Advanced Network Design: Developed lecture material, homework, and all other course related material for this new special topic, and taught it in Spring, 2005, and Fall, 2005, on a topic which fills a need in our curriculum. The course covers network design for static traffic, with brief introductions on optimization, graph theory, and complexity theory. Students are introduced to research in this area and also guided to identify and investigate open problems, teaching them the techniques of literature search, problem articulation, etc. This content has since been integrated into the CSC/ECE 778 - Optical Networking course.

CSC 772 – Survivable Network: This special topic was developed jointly by George Rouskas and myself, and we co-taught it for the first time in Spring, 2007 and again in Spring, 2008. In the past few decades, networks have attained critical infrastructure status, and continued operation in the face of equipment failure has become a mainstream issue. This course focuses on the theory, protocols, and research issues related to network fault-tolerance and survivability in large long-haul networks, as well as some coverage on survivability-related issues such as performability in wireless networks. These topics were not covered in our curriculum before the introduction of this course. This course has been graduated to a regular course, approved by the Graduate School, and is being offered regularly since.

ECE/CSC 777 – Telecommunications Network Design: This is a networking course cross-listed jointly with the ECE department, and has been taught solely by Dr. Arne Nilsson of the ECE department for the last several decades. Upon his impending retirement, this course appeared in danger of extinction, since Erlang theory (essential to the course) was not a current expertise of anybody else in the two departments interested in teaching it. Realizing the contemporary importance of the course in today's circuit-oriented networks, I took over the course, revamped it, creating new and contemporary teaching material, simulation and assignment material, and have started offering it on a regular basis.

CSC 495/591 – SDN Network Prototyping: This is a timely look at the newly emerging paradigm of Software Defined Networking. In this special topic, students not only learn about this paradigm in theoretical terms, but are guided into actually prototyping a programmed network functionality on commercial SDN hardware equipment. Different student groups or individuals work on different projects. This may in future become a regular course.

CSC 495/591 – Firefighting Drones: This is a multidisciplinary course on a cyber-physical challenge; this course is cross-listed with ECE and MAE special topics. Student groups were given building blocks and initial training to undertake the challenge of designing and developing a firefighting drone. In Fall, 2014, the challenge for each group was to design and develop any one of four modules delineated by instructors for such a drone. In Spring, 2015, the challenge for each group was to integrate these modules, redesigned as necessary, into a complete drone. This topic is not planned to transition to a regular course in its current form.

CSC/ECE 591/592 – Implementing Small IoT Systems: This is another topic I have offered to serve a timely need. It may in future become a regular course. This is a project-based course, in which the bulk of the semester is spent by students working in groups to perform projects leading to actual working systems. In this course, we introduce the various reference architectures proposed for IoT systems in the literature, then discuss the components in a common such architecture. We then briefly cover some component technologies, including a socket and kernel module programming refresher, and then introduce the BeagleBone Black platform. We will cover some basic sensor/actuator integration, data acquisition, and control issues. Following this, students will undertake, in small groups, projects that build small, but complete, IoT systems.

CSC/ECE 591/592/791/792 – Software Defined Networks: This course focuses on the recently-emerged paradigm of networking, which is causing the entire networking community, practitioners and researchers alike, to reexamine the basic tenets of the Internet. This extremely timely course focuses on the basic concepts of SDN, and specific technologies. Students spend the second half of the semester on a comprehensive group project to design both a traditional networking system and an SDN system that attempts to add the same additional functionality to a basic network, and compare the two solutions in various terms such as ease of development, efficiency of use, agility of modifications, etc. This builds on the CSC495/591 special topic taught by Dr. Dutta previously, and is being offered for the first time in Spring, 2017. It is likely to become a regular course.

CSC 801 Seminar – Preparing for Academic Research: This represents instructional development to address a shortcoming of the experience our department has thus far offered to our first-year PhD students. This shortcoming was uncovered by reflective thinking and investigation by a group of faculty, including myself, undertaken as a focus group exercise initiated by the department’s Strategic Planning Committee. We found a small but significant fraction of our incoming students, while having good academic credentials (and indeed, doing well in their coursework in our department), were nevertheless failing in their PhD work, either by not starting to work with an advisor early enough, or by not conducting such work effectively. Upon further investigation among current research students, some anecdotal evidence was found that indicated that this was actually a wider problem, and most of our student could potentially succeed better or earlier if systematic experiential instruction was provided early on to train them better in the expectations and processes of doctoral research work. In Fall, 2016, I created this seminar course to fill this gap, and taught it as an overload, with a small number of incoming PhD students. Feedback suggested that this was an effective measure, and in Fall, 2017, the department strongly suggested to all incoming students that they should take this course in their first semester; 28 of the 33 incoming students chose to do so. Response has been uniformly positive, and the department is considering making this a recurring process for future incoming batches, and possibly a required one.

Creation/Direction of University level Facility

Centennial Mesh Testbed: This testbed is an outdoor, highly programmable, extensible, open facility that we have built on the NCSU campus using open source code from NCSU students and faculty under my primary guidance. Its mission is to support research and education on the design of wireless mesh networks, as well as IT systems and applications enabled by wireless mesh networks. Availability of a testbed enables not only more successful and more practically useful research, but is indispensable in the teaching of such advanced topics as a hands-on laboratory. The CentMesh facility, developed using open source code built by NCSU students and faculty, provides such a resource. CentMesh is a highly realistic outdoor teaching lab, consisting of 14 permanent nodes and 8 mobile pushcart-mounted nodes – please see the “Technological and Managerial Innovation” section of this document for more details of this effort.

Campus Access Layer Architecture 2.0: In Dr. Dutta’s CC-NIE grant, he worked closely with the Director of the NCSU Office of Information Technology and NCSU’s Network Architect. In this project, NCSU ComTech was able to try out an envisioned upgrade of the Campus Access Layer Architecture to allow high-speed network services for researchers, and create high-speed network islands for research labs that need it. The CC-NIE project concluded in 2016. In the course of this project, 10 buildings were equipped with the new CALA switches, including EB2, allowing selected research spaces in these buildings to have access to 10 Gbps ports (previously all locations in NCSU had access to at most 1 Gbps ports). Over time, this can be rolled out over the whole campus. This new equipment also enables a future extension into the ability of the campus network to provide virtual “island” networks for physically distributed research facilities using the emerging Software Defined Networking paradigm. For more information, see Section I-C.

Creation of Departmental level Labs/Facilities

CPS testbed in EB2: Since Spring 2015, Dr. Dutta has been engaged in a project to establish a distributed testbed of small computing devices in EB2. These devices are small form-factor full-fledged Linux computers, but also have a broad range of I/O pins, allowing sensors and actuators to be easily plugged in. This will serve as a distributed facility for the teaching, and possibly also support research, in the area of Cyber-Physical Computing. The facility is reusing the back-end network connectivity previously created in EB2 for the Wisenet research testbed that Drs. Ning and Rhee installed, and that reached end-of-life around 10 years ago. The computing and sensing equipment that is being installed at those locations was acquired by Dr. Dutta on an ETF allocation.

CSC Networking Laboratory: In Fall, 2010, the College of Engineering offered a one-time opportunity to apply for large ETF funds, and I wrote a proposal to revamp and redesign the CSC departmental networking laboratory. I was pleased when the College awarded the full \$130K that I had requested; these funds have been used to purchase servers and switches as envisioned in the proposal, and re-equip the networking labs. In the current semester, it is supporting the teaching of some graduate courses, and will do so in future semesters to come. The new vision is driven by the changing nature of networking equipment. Of late, increasingly the functioning of networks is driven by software, running on commodity hardware. This has also prompted an explosion of such software systems, and it is desirable that

our graduates have exposure to a large number of such systems. Many such systems are available freely or as open-source alternatives, but require comparatively powerful computers and network switches. We have developed or adapted a series of such software environments that the students can use to have experience with a "network-in-a-box", with end stations, intermediate nodes, switches and routers operating as virtual machines inside compute-power-rich servers.

Internet Teaching Laboratory: I developed this laboratory in Spring 2000 since which time more than a thousand students have been through it. The first two sets of exercises currently accompany *CSC/ECE 573 – Internet Protocols*, the third set involves using the SmartBits network tester and has not been deployed for students due to lack of sufficient SmartBits boxes becoming available. This set of exercises was demonstrated at the CAIDA Internet Teaching Laboratories workshop at the University of Virginia at Charlottesville, VA, in summer 2001. A complete package to replicate the entire lab is available from the NC State Networking Laboratories site.

Virtual OPNET Laboratory: I obtained funding for and executed a project to allow distance students to have the same laboratory experience for *ECE/CSC 570 – Computer Networks* that in-class students do. Distance students are able to access a bank of servers directly using the Secure SHell (ssh) protocol. Access is blocked off for all other system users, except some administrative users, and is controlled for distance students using a web-based reservation system. Thus students obtain controlled access to OPNET without a processing bottleneck at public UNITY servers. The project was funded by DELTA, and supported a graduate student who implemented the system.

II. C. Master's and Doctoral Theses Directed

11 Ph.D. students and 21 MS students graduated.

In progress: 4 Ph.D. and 1 MS student.

Unless otherwise mentioned, Dutta is sole chair of advisory committee.

- Ph.D. Theses (*status change in 2017, currently in progress*)
 1. **"Impact of choice of mechanisms on policy effectiveness in Software Defined Networks", by William J Brockelsby – in progress, expected to graduate Spring, 2021 (passed written prelim in April, 2017).**
 2. **"Airborne computing networks algorithms", by Angelyn Arputha Babu John – in progress, expected to graduate Spring, 2021 (passed written prelim in April, 2017).**
 3. **"Architectural choices in security-as-a-service", by Harshvardhan Joshi – in progress, expected to graduate Spring, 2018 (passed written prelim in Fall, 2014).**
 4. **"Software Defined Networking as Choice Mechanism for Innovative Optical Networks", by Robinson Udechukwu – in progress, expected to graduate Spring, 2017 (passed oral prelim in Fall, 2015).**
 5. *"Service Definition for Automated Composability in the Choice-based Internet of the Future", by Shireesh Bhat – graduated Summer, 2017.*
 6. *"Studying and Quantifying Network Security Practices in Education in Emerging and Established Economies", by Magreth Mushi – graduated Summer, 2016.*
 7. *"Verification Services for the Choice-based Internet of the Future", by Ahmet Can Babagolu – graduated Spring, 2014. (chair: Dutta, co-chair: Rouskas)*
 8. *"Redundancy-based Approaches in Wireless Multihop Network Design", by Trisha Biswas – graduated Spring, 2014.*
 9. *"Efficient Decomposition Techniques for Traffic Grooming Problems in Optical Networks", by Hui Wang – graduated Spring, 2013. (chair: Rouskas, co-chair: Dutta)*
 10. *"Design for Survivability and Service Continuity in Wireless Mesh Networks", by Parth Pathak – graduated Summer, 2012.*
 11. *"Waveband grooming in hierarchical optical networks", by Mohan Iyer – graduated Summer, 2010 (chair: Rouskas, co-chair: Dutta).*
 12. *"The SILO architecture for the future Internet", by Anjing Wang – graduated Summer, 2010 (chair: Dutta, co-chair: Rouskas).*
 13. *"Measurements and Analysis of the Performance Characteristics of SIP Proxy Servers", by Suresh Subramaniam – graduated Summer, 2010.*
 14. *"Quasi-Dynamic Traffic Grooming in Optical Networks", by Shu Huang – graduated Summer, 2006.*

15. “Hierarchical Traffic Grooming in Large-Scale WDM Networks”, by Bensong Chen – graduated Summer 2005 (chair: Dutta, co-chair: Rouskas).
- M.S. Theses (*status change in 2017, currently in progress*)
 1. “**Network agility for IoT networks with mobile airborne nodes**”, by **Pritesh Ranjan – in progress (expected to graduate Summer, 2018)**.
 2. “Comparative Study of a Proposed OpenFlow Agent Enhancement to Support Flexible Payload Match”, by Ramachandra Kasyap Marmavula – graduated Summer, 2014.
 3. “Design of a flexible, extensible interface for the CentMesh architecture for auxiliary sensing devices”, by Ashutosh Grewal – graduated Summer, 2012.
 4. “Adaptive Channel Width Allocation for Multihop Wireless Networks with Joint Scheduling and Congestion Control”, by Sankalp Nimbhorkar – graduated Spring, 2012.
 5. “A Cooperative Approach to Mitigating Sybil Attack in Wireless Sensor Networks”, by Gaurang Sinkar – graduated Fall, 2011.
 6. “Packet Aggregation Based Backpressure Scheduling in Multi-hop Wireless Networks”, Gaurish Deuskar – graduated Summer, 2010.
 7. “A Routing Approach to Jamming Effects Mitigation in Wireless Multihop Networks”, by Umang Patel – graduated Fall, 2010.
 8. “Differential Capacity p-Cycles”, by Prashant Jaikumar – graduated Fall, 2008.
 9. “Green Grooming: power awareness in the wired backbone”, by Deepa Seshadri – graduated Summer, 2008.
 10. “A SILO testbed for wired/wireless applications” (tentative title), by Manoj Vellala – graduated Spring, 2008.
 11. “End-to-end Behavior of Delay Tolerant Networks with Message Ferries”, by Dheeraj Kandula – graduated Spring, 2008.
 12. “Optimization of the processing in a middleware environment for a set of XML variants”, by Vineet Sahijwani – graduated Fall, 2006.
 13. “Design and Implementation of a Distributed Scheduling Algorithm for Sensor Networks using Period Inflation”, by Bhushan Bhatt – graduated Fall, 2006.
 14. “Joint Modeling of Mobility and Communication in Vehicular Networks”, by Pritesh Patwa – graduated Summer, 2006.
 15. “Throughput and Delay Characteristics in Multihop Wireless Networks”, by Divya Gupta – graduated Summer, 2006.
 16. “An Automatic, Adaptive, Ad-hoc Algorithm for Power Conservation in Sensor Networks using Switch-off”, by Sharat Visweswara – graduated Summer, 2004.
 17. “Protection in survivable WDM grooming network”, by Ruarob Tiyachate – graduated Spring, 2004.
 18. “Power Conservation in Wireless Sensor Networks using Switch-off”, by Apurva Goel – graduated Spring, 2004.
 19. “Reconfiguration of Sub-wavelength Groomed Wavelength Routed Optical Networks”, by Ruhiiyih Mahalati – graduated Fall, 2003.
 20. “Traffic Grooming in Translucent Optical Ring Networks”, by Koundinya Srinivasarao – graduated Summer, 2003.
 21. “The Complexity of Traffic Grooming in Optical Path Networks with Egress Traffic”, by Prashant Iyer – graduated Spring, 2003 (chair: Savage, co-chair: Dutta).
 22. “Traffic Grooming in Wavelength Routed Path Networks”, by Shu Huang – graduated Spring, 2003.

III. Scholarship in the Realms of Faculty Responsibility

III. A. Research Publications

My h-index is 24, i10-index is 54, total citations over 3000 (source: Google Scholar, as of January 19, 2018). My Google Scholar profile is available; search or see link from my website.

29 journal papers, 73 peer-reviewed conference papers, 7 peer-reviewed workshop papers.

Peer-Reviewed Journal Publications

ISI Journal Impact Factors (JIF) are included where available – for the rest this information was unavailable. Individual top citations: [J26] and [J28] each has over 450 citations (source: Google Scholar).

- **Submitted:**
 - Takaya Miyazawa, Hiroaki, Harai, Robinson Udechukwu, Rudra Dutta, “Designing and Experimentally Demonstrating Automatic OPS/OCS/OpenFlow Network Control Driven by ChoiceNet Provider”, submitted to Photonic Network Communications.
- **Published:**
 - J1. Mushi, Magreth, and Rudra Dutta. "Human Factors in Network Reliability Engineering." *Journal of Network and Systems Management*: 1-37 (online: November, 2017).
 - J2. Shireesh Bhat, Robinson Udechukwu, Rudra Dutta, George Rouskas, “Network Service Orchestration in Heterogeneous 5G Networks using an Open Marketplace”, *IET Networks*, 6(6), pp. 149-156, September, 2017.
 - J3. Harshvardhan Joshi, Aravindhan Dhanasekaran, Rudra Dutta, “Trading Off a Vulnerability: Does Software Obfuscation Increase the Risk of ROP Attacks”, *Journal of Cyber Security and Mobility*, Vol 4, Issue 4, pages 305-324, October 2015.
 - J4. Xiaofan He, Huaiyu Dai, Peng Ning, Rudra Dutta, “A Leader-follower Controlled Markov Stopping Game for Delay Tolerant and Opportunistic Resource Sharing Networks”, *IEEE Journal on Selected Areas in Communications*, (to be published in print form), DOI: 10.1109/JSAC.2017.2659581, January, 2017.
 - J5. Xiaofan He, Huaiyu Dai, Wenbo Shen, Peng Ning, Rudra Dutta, “Towards Proper Guard Zones for Link Signature”, *IEEE Transactions on Wireless Communications*, Vol 15, Issue 3, pages 2104-2117, March 2016.
 - J6. Xiaofan He, Huaiyu Dai, Peng Ning, Rudra Dutta. “Zero-determinant Strategies for Multi-player Multi-action Iterated Games”, *IEEE Signal Processing Letters*, Vol 23, Issue 3, pages 311-315, January 2016.
 - J7. Parth Pathak, Rudra Dutta, Prasant Mohapatra, “On Availability-Performability Trade-off in Wireless Mesh Networks”, *IEEE Transactions on Mobile Computing*, Vol 14, Issue 3, Pages 606-618, March 2015.
 - J8. Tilman Wolf, Jim Griffioen, Ken Calvert, Rudra Dutta, George Rouskas, Ilya Baldin, Anna Nagurney, “ChoiceNet: Toward an Economy Plane for the Internet”, *ACM Computer Communication Review*, Pages 58-65, Vol 44, Issue 3, July 2014.
 - J9. Anjing Wang, George N Rouskas, Rudra Dutta, “Network Virtualization: Technologies, Perspectives, and Frontiers”, *IEEE/OSA Journal of Lightwave Technology*, 31(4), pp. 523-537, February 2013. Digital Object Identifier: 10.1109/JLT.2012.2213796.
 - J10. Tilman Wolf, James Griffioen, Kenneth L Calvert, Rudra Dutta, George N Rouskas, Ilya Baldine, Anna Nagurney, “Choice as a principle in network architecture”, *ACM SIGCOMM Computer Communication Review*, Volume 42, Issue 4, Pages 105-106, September, 2012.
 - J11. Parth Pathak, Rudra Dutta, “Centrality-based power control for hot-spot mitigation in multi-hop wireless networks”, in *Computer Communications (Elsevier) Journal*, Special Issue on Wireless Sensor and Robot Networks: Algorithms and Experiments, Volume 35, Issue 9, 15 May 2012, Pages 1074–1085.
 - J12. SV Subramanian, R Dutta, “A study of performance and scalability metrics of a SIP proxy server-a practical approach” in *Journal of Computer and System Sciences*, vol. 77 no. 5, pp 884-897, Sep 2011.
 - J13. Joe Touch, Ilya Baldine, Rudra Dutta, Gregory G Finn, Bryan Ford, Scott Jordan, Dan Massey, Abraham Matta, Christos Papadopoulos, Peter Reiher, George Rouskas, “A Dynamic Recursive Unified Internet Design (DRUID)”, in *Elsevier Computer Networks*, Volume 55 Issue 4, March, 2011. DOI: 10.1016/j.comnet.2010.12.016

- J14. Prashant Jaikumar, Rudra Dutta, "Differential Capacity p-Cycles: A p-Cycle Variant with Increased Capacity Efficiency", Elsevier Optical Switching and Networking, Vol 7, No 4, December 2010, pp 185-195. DOI: 10.1016/j.osn.2010.05.002
- J15. Bensong Chen, Rudra Dutta, George Rouskas, "Clustering Methods for Hierarchical Traffic Grooming in Large Scale Mesh WDM Networks", Journal of Optical Communications and Networking (previously the OCN series in IEEE Journal on Selected Areas in Communications), vol. 2. No.8, pp 502-514, August 2010.
- J16. Parth Pathak, Rudra Dutta, "A Survey of Joint Design Methods for Wireless Mesh Networks", IEEE Communications Surveys and Tutorials, vol 13, no. 3, pp 396-428, June 2010.
- J17. Prashant Iyer, Rudra Dutta, Carla Savage, "Minimizing Transceivers in Optical Path Networks", OSA Journal of Optical Networking, Vol. 8, Iss. 5, pp. 454-461, May, 2009.
- J18. Bensong Chen, Rudra Dutta, George Rouskas, "On Hierarchical Traffic Grooming in WDM Networks", IEEE/ACM Transactions on Networking vol. 16, no. 5, pages 1226-1238, December 2008.
- J19. Shu Huang, Rudra Dutta, "Spare Capacity Provisioning for Quasi-static Traffic", Computer Networks (Elsevier), Volume 51, Issue 18, 2007, Pages 5011-5035.
- J20. Prashant Iyer, Rudra Dutta, Carla Savage, "The Complexity of Path Traffic Grooming", OSA Journal of Optical Networking, Vol. 6 Issue 11, pp.1270-1281 (2007).
- J21. Shu Huang, Rudra Dutta, "Dynamic Traffic Grooming: The Changing Role of Traffic Grooming", in IEEE Communications Surveys and Tutorials, ISSN: 1553-877X, 2007, Volume 9, Number 1, pages 32-50, Digital Object Identifier: 10.1109/COMST.2007.358970.
- J22. Mihail Sichitiu, Rudra Dutta, "On the Lifetime of Large Wireless Sensor Networks with Multiple Battery Levels", in Ad Hoc and Sensor Wireless Networks vol. 4, no. 1-2, pp. 69-96, 2007.
- J23. Sharat Visweswara, Rudra Dutta, Mihail Sichitiu, "Adaptive Ad-hoc Self-Organizing Scheduling for Quasi-Periodic Sensor Network Lifetime", Elsevier Computer Communications Journal, Volume 29 (2006), pages 3366-3384 (2005 JIF: 0.556).
- J24. Shu Huang, Rudra Dutta, George Rouskas, "Traffic Grooming in Path, Star, and Tree Networks", Journal on Selected Areas in Communications, Vol 24, No 4, April, 2006, pp. 66-82 (2005 JIF: 2.698).
- J25. Koundinya B. Srinivasarao, Rudra Dutta, "Traffic-partitioning approaches to Grooming Ring Access Networks", OSA Journal of Optical Networking Vol 4, No 9, September, 2005, pp. 602-614.
- J26. Bensong Chen, George Rouskas, Rudra Dutta, "Traffic Grooming in WDM Ring Networks to Minimize the Maximum Electronic Port Cost", Optical Switching and Networking, Elsevier, Vol 2 No 1, May, 2005, pp 1-18.
- J27. Rudra Dutta, George Rouskas, "Traffic Grooming in WDM Networks: Past and Future", IEEE Network, Vol 16, No. 6, pp. 46-56, Nov-Dec 2002 (2003 JIF: 3.871, 2004 JIF: 2.667).
- J28. Rudra Dutta, George Rouskas, "On Optimal Traffic Grooming in WDM Rings", IEEE Journal on Selected Areas in Communications, Vol 20, No 1, pp. 110-121, January, 2002 (2003 JIF: 1.967, 2004 JIF: 2.640).
- J29. Rudra Dutta, George Rouskas, "A Survey of Virtual Topology Design Algorithms for Wavelength Routed Networks", Optical Networks (SPIE), Vol 1, No 1, pp. 73-89, January 2000.

Book Chapters

- **Published**

1. Rudra Dutta, Ilia Baldine, "Architectural Support for Continuing Internet Evolution and Innovation", in Next-Generation Internet Architectures and Protocols, (Byrav Ramamurthy, George Rouskas, Krishna Sivalingam, Editors), Cambridge University Press, 2010.
2. George N. Rouskas, Rudra Dutta, "Hierarchical Traffic Grooming," in Traffic Grooming for Optical Networks: Foundations and Techniques, (Rudra Dutta, Ahmed E. Kamal, and George N. Rouskas, Editors), Springer, 2008.
3. Rudra Dutta, Ahmed E. Kamal, George N. Rouskas, "Grooming Mechanisms in SONET/SDH and Next-Generation SONET/SDH," in Traffic Grooming for Optical Networks: Foundations and Techniques, (Rudra Dutta, Ahmed E. Kamal, and George N. Rouskas, Editors), Springer, 2008.
4. "Chapter 4: Design of Logical Topologies for Wavelength Routed Networks", by Rudra Dutta and George Rouskas, in Krishna Sivalingam and Suresh Subramanian (eds.) Optical WDM Networks: Principles and Practice, Kluwer, Norwell, MA, pp. 79-102, 2000.

Books (Authored)

1. "Measuring SIP Proxy Server Performance", by Sureshkumar V Subramanian and Rudra Dutta, Springer, 2013, ISBN: 978-3319009896

2. “Designing for Network and Service Continuity in Wireless Mesh Networks”, by Parth H. Pathak and Rudra Dutta, Springer, 2012, ISBN: 978-1461446262

Books (Edited)

1. “An Introduction to Traffic Grooming for Optical Networks: Foundations, Techniques, and Horizons”, edited by Rudra Dutta, Ahmed Kamal, George N. Rouskas, Springer, 2008.

Conference Proceedings (Edited)

1. Rudra Dutta, Eytan Modiano, Yi Qian (TPC co-chairs), Proceedings of Design of Reliable Communications Networks (DRCN) 2015.
2. Rudra Dutta, Krishna Sivalingam (General co-chairs), Proceedings of the Fourth IEEE Advanced Networking and Telecommunications Systems conference, IEEE Digital Object Identifier: 10.1109/ANTS.2010.5983508
3. Rudra Dutta, Krishna Sivalingam (TPC co-chairs), Proceedings of the Third IEEE Advanced Networking and Telecommunications Systems conference, IEEE Digital Object Identifier : 10.1109/ANTS.2009.5409897
4. Rudra Dutta and Ahmed Kamal (editors), Proceedings of the Second International IEEE/Create-Net Workshop on Traffic Grooming, IEEE Catalog Number: 05EX1116C, ISBN: 0-7803-9277-9, October, 2005, Boston, MA.

Journal Special Issues (Guest Edited)

1. Journal of Network and Systems Management, Special Issue on Survivable and Resilient Communication Networks and Services, July, 2016.
2. Elsevier Journal of Optical Switching and Networking, Special Issue on IEEE ANTS 2012, Volume 11, Issue 18 (2015)
3. Elsevier Journal of Optical Switching and Networking, Special Issue on IEEE ANTS 2011, Volume 10, Issue 4 (2013)
4. Elsevier Journal of Optical Switching and Networking, Special Issue on IEEE ANTS 2010, Volume 9, Issue 2 (2012)
5. Elsevier Journal of Optical Switching and Networking, Special Issue on Green Communications and Networking, Volume 8, Issue 3 (2011)
6. Elsevier Journal of Optical Switching and Networking, Special Issue on IEEE ANTS 2009, Volume 7, Issue 4 (2010)

Peer-Reviewed Conferences and Workshops

Acceptance rates are noted wherever available – for the rest this information was unavailable.

- **Submitted**
 - Russell Meredith, Natalie Landsberg, Agueo Lopez, Rudra Dutta and Douglas Reeves, “Recovering an OSPF Network from Malicious Attacks: An Experimental Evaluation of Recovery Techniques”, submitted to HotSoS 2018.
- **Published Conference Papers**
 1. John, Angelyn Arputha Babu, and Rudra Dutta. "Cooperative trajectory planning in an intercommunicating group of UAVs for convex plume wrapping." In *Sarnoff Symposium, 2017 IEEE 38th*, pp. 1-6. IEEE, 2017.
 2. Udechukwu, Robinson, Rudra Dutta, Takaya Miyazawa, and Hiroaki Harai. "Toward realizing choice-based co-optimizable networking paradigm." In *Sarnoff Symposium, 2017 IEEE 38th*, pp. 1-6. IEEE, 2017.
 3. Joshi, Harshvardhan P., Matthew Bennison, and Rudra Dutta. "Collaborative botnet detection with partial communication graph information." In *Sarnoff Symposium, 2017 IEEE 38th*, pp. 1-6. IEEE, 2017.
 4. Udechukwu, Robinson, Rudra Dutta, Takaya Miyazawa, and Hiroaki Harai. "Evaluating Different Pricing Algorithms for a Flexible Optical Choice-Based Network." In *Computer Communication and Networks (ICCCN), 2017 26th International Conference on*, pp. 1-2. IEEE, 2017.
 5. Bhat, Shireesh, Robinson Udechukwu, Rudra Dutta, and George N. Rouskas. "On service composition algorithm for Open Marketplaces of network services." In *Networks and Communications (EuCNC), 2017 European Conference on*, pp. 1-6. IEEE, 2017.
 6. Jin, Richeng, Xiaofan He, Huaiyu Dai, Rudra Dutta, and Peng Ning. "Towards Privacy-Aware Collaborative Security: A Game-Theoretic Approach." In *2017 IEEE Symposium on Privacy-Aware Computing (PAC)*, pp. 72-83. IEEE, 2017.

7. Robinson Udechukwu, Shireesh Bhat, Rudra Dutta, George Rouskas, "Language of choice: On embedding choice-related semantics in a realizable protocol", 37th IEEE Sarnoff Symposium, September 2016, pages 31-36.
8. Xiaofan He, Huaiyu Dai, Peng Ning, Rudra Dutta "A Multi-player Markov Stopping Game for Delay-tolerant and Opportunistic Resource Sharing Networks", IEEE INFOCOM, April, 2016.
9. Harshvardhan Joshi, Rudra Dutta, "Impact of Software Obfuscation on Susceptibility to Return-Oriented Programming Attacks", the 36th IEEE Sarnoff Symposium, 2015.
10. Xiaofan He, Huaiyu Dai, Peng Ning, Rudra Dutta, "Dynamic IDS Configuration in the Presence of Intruder Type Uncertainty", IEEE Globecom, December, 2015.
11. Xiaofan He, Huaiyu Dai, Peng Ning, Rudra Dutta, "A Stochastic Multi-channel Spectrum Access Game with Incomplete Information", IEEE International Conference on Communications, June, 2015.
12. Xinming Chen, Tilman Wolf, James Griffioen, Onur Ascigil, Rudra Dutta, George N. Rouskas, Shireesh Bhat, Ilya Baldin, Ken Calvert, "Design of a Protocol to Enable Economic Transactions for Network Services", IEEE International Conference on Communications, June, 2015.
13. Robinson Udechukwu, Rudra Dutta, "Service Definition Semantics for Optical Services on a Choice-based Network", Optical Network Design and Modeling (ONDM), May, 2015.
14. Magreth Mushi, Emerson Murphy-Hill, Rudra Dutta, "The Human Factor: a Challenge for Network Reliability Design", Design of Reliable Communication Networks (DRCN) 2015, March, 2015.
15. Ahmet C Babaoglu, Rudra Dutta, "Grooming Demands instead of Traffic: Benefits of a Choice-Based Approach to Green Optical Networks", IEEE Globecom 2014, pp 2029-2035, December 2014.
16. Trisha Biswas, Rudra Dutta, "Reliability prediction of diffused pathset routing in wireless multihop networks", IEEE Globecom 2014, pp 1290-1295, December 2014.
17. Trisha Biswas, Kendra Lesser, Rudra Dutta, Meeko Oishi, "Using linear system reliability to obtain theoretical understanding of wireless routing", IEEE Globecom 2014, pp 1310-1316, December 2014.
18. Robinson Udechukwu, Rudra Dutta, "Extending Openflow for Service Insertion and Payload Inspection", 2014 IEEE 22nd International Conference on Network Protocols (ICNP), pp 589-595, October, 2014.
19. Rudra Dutta, George N Rouskas, Ilya Baldin, "Traffic Grooming: Balancing Choice and Service in Optical Networks", Advanced Photonics for Communications, San Diego, CA, July 2014.
20. Trisha Biswas, Kendra Lesser, Rudra Dutta, Meeko Oishi, "Examining reliability of wireless multihop network routing with linear systems", in Proceedings of the 2014 Symposium and Bootcamp on the Science of Security, ACM, April 2014.
21. Ahmet C Babaoglu, Rudra Dutta, "A Verification Service Architecture for the Future Internet", in 22nd International Conference on Computer Communications and Networks (ICCCN), Nassau, Bahamas, July 2013.
22. Rudra Dutta, George Rouskas, Ilia Baldine, "Converging choice and service in future commodity optical networks using traffic grooming", in 15th International Conference on Transparent Optical Networks (ICTON), Cartagena, Spain, June 23-27, 2013.
23. George Rouskas, Ilia Baldine, Ken Calvert, Rudra Dutta, James Griffioen, Anna Nagurney, Tilman Wolf, "ChoiceNet: Network Innovation Through Choice", in 17th International Conference on Optical Network Design and Modeling (ONDM), Telecom Bretagne, Brest, France April 16-19, 2013.
24. Tilman Wolf, James Griffioen, Kenneth Calvert, Rudra Dutta, George Rouskas, Ilia Baldine, Anna Nagurney, "Choice as a Principle in Network Architecture", in ACM SIGCOMM, 2012, Helsinki, August 13 – 17.
25. Parth H. Pathak, Sankalp Nimbhorkar, Rudra Dutta, "Channel width assignment using relative backlog: extending back-pressure to physical layer", In Proceedings of the thirteenth ACM international symposium on Mobile Ad Hoc Networking and Computing (MobiHoc '12), pp. 249-250. DOI=10.1145/2248371.2248409
26. Gaurish Deuskar, Parth Pathak, Rudra Dutta, "Packet Aggregation Based Back-pressure Scheduling in Multi-hop Wireless Networks", in Proceedings of IEEE WCNC 2011, Paris, France, April, 2012.
27. Trisha Biswas, Rudra Dutta, "Spatially Diffuse Pathsets for Robust Routing in Ad Hoc Networks", in Proceedings of IEEE Globecom 2011, Dec 2011, Houston, Texas, pp 1-6, ISBN: 978-1-4244-9266-4, doi : 10.1109/GLOCOM.2011.6133499, IEEE.
28. Ahmet Babaoglu, Rudra Dutta, "Benefits of Multi Wavelength Approach to Converter Placement to Support Broadcast with Available Wavelengths", in Proceedings of IEEE Globecom 2011, Dec 2011, Houston, Texas, pp 1-6, ISBN: 978-1-4244-9266-4, doi: 10.1109/GLOCOM.2011.6134393, IEEE.

29. Ahmet Babaoglu, Rudra Dutta, "Performance Impact of Architectural Decisions: Integrating Measurement in SILO", in Proceedings of 6th International Conference on Future Internet Technologies, Seoul, Korea, 13-15 June 2011, pp 72-78, ISBN: 978-1-4503-0821-2 doi:10.1145/2002396.2002417, ACM.
30. Parth Pathak, Rudra Dutta, "Impact of Power Control on Capacity of TDM-scheduled Wireless Mesh Networks", in Proceedings IEEE ICC 2011, June 2011, Kyoto, Japan, ISBN: 978-1-61284-232-5, doi: 10.1109/icc.2011.5962410, IEEE.
31. Michael Wang, Anjing Wang, Balagangadhar Bathula, Caroline Lai, Ilia Baldine, Cathy Chen, Debjyoti Majumder, Deniz Gurkan, George Rouskas, Rudra Dutta, Keren Bergman, "Demonstration of QoS-Aware Video Streaming over a Metro-Scale Optical Network Using a Cross-Layer Architectural Design", in Proceedings of Optical Fiber Conference (OFC/NFOEC), 2011, Los Angeles, California, March 6, 2011.
32. Rudra Dutta, Ilia Baldine, Anjing Wang, Mohan Iyer, George N Rouskas, "Architectural support for Internet evolution and innovation", in Proceedings of IEEE 4th International Symposium on Advanced Networks and Telecommunication Systems (ANTS), Dec 2010, Mumbai, India, pp1-3, ISBN: 978-1-4244-9852-9, doi: 10.1109/ANTS.2010.5983509, IEEE.
33. Parth Pathak, Rudra Dutta, "Using Centrality-based Power Control for Hot-spot Mitigation in Wireless Networks", in Proceedings IEEE Globecom 2010, Miami, FL, Dec 2010, ISBN: 978-1-4244-5636-9, doi: 10.1109/GLOCOM.2010.5683097
34. Sureshkumar Subramanian, Rudra Dutta, "Performance Measurements and Analysis of M/M/c Queuing Model Based SIP Proxy Servers in Local and Wide Area Networks", in International Conference on Advances in Recent Technologies in Communication & Computing (ARTCom), 2010.
35. Sureshkumar Subramanian, Rudra Dutta, "Comparative Study of Secure vs Non-Secure Transport Protocols on the SIP Proxy Server Performance: An Experimental Approach", in International Conference on Advances in Recent Technologies in Communication & Computing (ARTCom), 2010.
36. Parth Pathak, Rudra Dutta, "Impact of Power Control on Relay Load Balancing in Wireless Sensor Networks", in Proc. IEEE Wireless Communications and Networking Conference (WCNC) 2010, Sydney, Australia, April, 2010 (Acceptance: 37%).
37. JunBum Lim, Parth Pathak, Mani Pandian, Umang Patel, Gaurish Deuskar, Akshata Danivasa, Rudra Dutta, Mihail Sichitiu, "CentMesh: Modular and Extensible Wireless Mesh Network Testbed", in Proc. TESTBEDS AND RESEARCH INFRASTRUCTURES. DEVELOPMENT OF NETWORKS AND COMMUNITIES, (TridentCom), 2010, Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering, 2011, Volume 46, Part 12, 619-621, DOI: 10.1007/978-3-642-17851-1_59.
38. Prashant Jaikumar, Rudra Dutta, "Differential Capacity p-Cycles: A p-Cycle Variant with Increased Capacity Efficiency", in Proc. IEEE Advanced Network and Telecommunications Systems (ANTS), December, 2009 (acceptance rate: 25% for oral presentations).
39. Parth Pathak, Rudra Dutta, "Impact of Power Control on Capacity of Large Scale Wireless Mesh Networks", in Proc. IEEE Advanced Network and Telecommunications Systems (ANTS), December, 2009 (acceptance rate: 25% for oral presentations).
40. Suresh Subramanian, Rudra Dutta, "Performance and Scalability of M/M/c Based Queuing Model of the SIP Proxy Server – A Practical Approach", Proc. IEEE ATNAC 2009.
41. Parth Pathak, Dheeraj Kandula, Rudra Dutta, "MF-TCP : Design and Evaluation of TCP for Message Ferry Delay Tolerant Networks", Proc. IEEE ATNAC 2009.
42. Shu Huang, Deepa Seshadri, Rudra Dutta, "Traffic Grooming: a Changing Role in Green Optical Networks", IEEE Globecom 2009, IEEE Xplore DOI: 10.1109/GLOCOM.2009.5425630 (Acceptance rate: 34%)
43. Suresh Subramanian, Rudra Dutta, "Measurements and Analysis of M/M/1 and M/M/c Queuing Models of the SIP Proxy Server", in Proceedings of 3rd IEEE International Workshop on Performance Modeling and Evaluation in Computer and Telecommunication Networks (PMECT2009) co-located with IEEE ICCCN 2009, (Acceptance rate: 29%) IEEE Xplore Digital Object Identifier: 10.1109/ICCCN.2009.5235282 .
44. Suresh Subramanian, Rudra Dutta, "Comparative Study of M/M/1 and M/D/1 Models Of a SIP Proxy Server", in Proceedings of IEEE Australasian Telecommunication Networks and Applications Conference (ATNAC), IEEE Cat. No. CFP0818D-CDR, ISBN 978-1-4244-2603-4, Library of Congress 2008904865, December, 2008, Adelaide, Australia (Acceptance rate: 40%), pages 397-402, IEEE Xplore Digital Object Identifier: 10.1109/ATNAC.2008.4783357.

45. Parth Pathak, Divya Gupta, Rudra Dutta, "Loner Links Aware Routing and Scheduling in WMNs", in Proceedings of IEEE Advanced Network and Telecommunications Systems (ANTS), December, 2008 (Acceptance rate: 31%).
46. Mohan Iyer, Rudra Dutta, George Rouskas, "A Hierarchical Model for Multigranular Optical Networks", in Proceedings of BroadNets, 2008, pp. 444-451, IEEE Xplore DOI: 10.1109/BROADNETS.2008.4769124 (Acceptance rate: 43%).
47. Ilia Baldine, Jeff Chase, George Rouskas, Rudra Dutta, "At-scale experimentation with resource virtualization in a metro optical testbed", in Proceedings of ICVCI, 2008, May, 2008.
48. Manoj Vellala, Anjing Wang, George N. Rouskas, Rudra Dutta, Ilia Baldine, Dan Stevenson, "A Composition Algorithm for the SILO Cross-Layer Optimization Service Architecture". In Proceedings of the Advanced Networks and Telecommunications Systems Conference (ANTS 2007), December 17-18, Mumbai, India (CD-ROM publication – no page numbers).
49. Dan Stevenson, Rudra Dutta, George Rouskas, Douglas Reeves, Ilia Baldine, "On the Suitability of Composable Protocols for the Assurable Future Internet", in Proceedings of MILCOM 2007, page(s): 1-7, ISBN: 978-1-4244-1513-7, IEEE Xplore Digital Object Identifier: 10.1109/MILCOM.2007.4455045
50. SuYoung Yoon, Rudra Dutta, Mihail Sichitiu, "Power Aware Routing Algorithms for Wireless Sensor Networks", in Proceedings of the Third International Conference on Wireless and Mobile Communications (ICWMC), 2007, March 2007, pages 15-15, ISBN: 0-7695-2796-5, IEEE Xplore Digital Object Identifier: 10.1109/ICWMC.2007.69
51. Pritesh Patwa, Rudra Dutta, "Joint Modeling of Mobility and Communication in a V2V Network for Congestion Amelioration", in Proceedings of the Sixteenth International Conference on Computer Communications and Networks (ICCCN) 2007, pages 575-582 (Acceptance rate: 28%), August, 2007, Honolulu, Hawaii.
52. Ilia Baldine, Dan Stevenson, Manoj Vellala, Anjing Wang, George Rouskas, Rudra Dutta, "A Unified Software Architecture to Enable Cross-Layer Design in the Future Internet", in Proceedings of the Sixteenth International Conference on Computer Communications and Networks (ICCCN) 2007, pages 26-32 (Acceptance rate: 28%), August, 2007, Honolulu, Hawaii.
53. Bensong Chen, George N. Rouskas, Rudra Dutta, "Clustering for Hierarchical Traffic Grooming in Large Scale Mesh WDM Networks", in Proceedings of the 11th International Conference on Optical Networking Design and Modeling (ONDM) 2007, LNCS 4534, pp. 249-258, May 29-31, Athens, Greece.
54. Rudra Dutta, George N. Rouskas, Ilia Baldine, Arnold Bragg, Dan Stevenson, "The SILO Architecture for Services Integration, control, and Optimization for the Future Internet", in Proceedings of IEEE International Conference on Communications (ICC), 2007, 24-28 June 2007 Page(s):1899 – 1904, IEEE Xplore Digital Object Identifier 10.1109/ICC.2007.316.
55. Shu Huang, Rudra Dutta, "Design of Wireless Mesh Networks under the Additive Interference Model", in Proceedings of ICCCN 2006, pp. 253-260, ISBN: 0-4224-0572-6, IEEE Catalog Number: 06EX1500. (Acceptance rate: 28%)
56. Prashant Iyer, Rudra Dutta, Carla Savage, "Complexity of Converter Placement Supporting Broadcast in WDM Networks", in Proceedings of BroadNets 2006, October, 2006, San Jose, CA, ISBN: 1-4244-0425-8, (Acceptance rate: 43%) (CD-ROM publication – No page numbers).
57. Shu Huang, Rudra Dutta, "Spare Capacity Provisioning for Dynamic Traffic Grooming in Optical Networks", in Proceedings of BroadNets 2006, October, 2006, San Jose, CA, ISBN: 1-4244-0425-8 (Acceptance rate: 43%) (CD-ROM publication – No page numbers).
58. Bensong Chen, George N. Rouskas, Rudra Dutta, "Clustering Methods for Hierarchical Traffic Grooming in Large Scale Mesh WDM Networks", in Proceedings of the Fifth International Symposium on Communication Systems, Networks And Digital Signal Processing, pp. 55-59, (Acceptance rate: 45%) Patras, Greece, July, 2006 (received BEST PAPER award).
59. Rudra Dutta, Carla Savage, "A Note on the Complexity of Converter Placement Supporting Broadcast in WDM Optical Networks", in Proceedings of the International Conference on Telecommunication Systems - Modeling and Analysis, pp. 23-31, ISBN: 0-9716253-3-6, Dallas, TX, November, 2005.
60. Ruarob Tiyachate, Rudra Dutta, "Subwavelength Traffic Protection without Sacrificing Grooming Performance", in Proceedings of the 4th International Conference on Optical Communications and Networks, pp. 151-154, ISBN: 974-7990-86-5, December, 2005, Bangkok, Thailand.
61. Shu Huang, Rudra Dutta, "On Optimal Single Link Allocation of Spare Capacity for Dynamic Traffic Grooming", in Proceedings of the International Conference on Telecommunication Systems - Modeling and Analysis, pp. 255-264, ISBN: 0-9716253-3-6, Dallas, TX, November, 2005.

62. Prashant Iyer, Rudra Dutta, Carla D. Savage, "On the Complexity of Path Traffic Grooming", in Proceedings of the Second International IEEE/Create-Net Workshop on Traffic Grooming, pp. 308-314, IEEE Catalog Number: 05EX1116C, ISBN: 0-7803-9277-9, October, 2005, Boston, MA.
 63. Chih-Chieh Hsu, Rudra Dutta, "Providing End-to-End Delay Requirements in Heterogeneous Networks using Zone Delay Assignment", in Proceedings of the Third International Conference on the Performance Modeling and Evaluation of Heterogeneous Networks (HET-NETs), pp. P56/1 – P56/10, ISBN: 0-9550624-0-3, July, 2005, West Yorkshire, England.
 64. Bensong Chen, Rudra Dutta, George Rouskas, "On the Application of K-Center Algorithms in Hierarchical Traffic Grooming", in Proceedings of the Second International IEEE/Create-Net Workshop on Traffic Grooming, pp. 295-301, IEEE Catalog Number: 05EX1116C, ISBN: 0-7803-9277-9, October, 2005, Boston, MA.
 65. Koundinya B. Srinivasarao, Rudra Dutta, "Traffic-partitioning approaches to Grooming Ring Networks", in Proceedings of Joint International Conference on Autonomic and Autonomous Systems and International Conference on Networking and Services, pp. 6.1-6.6, (Acceptance rate: 42%) ISBN: 0-7695-2450-8, Library of Congress No. 2005934165, October, 2005, Papeete ,Tahiti.
 66. Bensong Chen, George Rouskas, Rudra Dutta, "A Framework for Hierarchical Traffic Grooming in WDM Networks of General Topology", in Proceedings of IEEE/Create-Net BroadNets 2005, pp. 167-176, (Acceptance rate: 33%) IEEE Catalog Number: 05EX1116C, ISBN: 0-7803-9277-9, October, 2005, Boston, MA.
 67. Mihail Sichitiu, Rudra Dutta, "Benefits of Multiple Battery Levels for the Lifetime of Large Wireless Sensor Networks", in Proceedings of Networking 2005, LNCS Vol. 3462, pp. 1440-1444, (Acceptance rate: 32%) ISBN: 3-540-25809-4, May, 2005, Waterloo, Canada.
 68. Sharat C. Visweswara, Apurva A. Goel, Rudra Dutta, "An Adaptive Ad-hoc Self-Organizing Scheduling Method for Quasi-Periodic Sensor Traffic", in Proceedings of the First IEEE Communications Society Conference on Sensor and Ad Hoc Communications and Networks (SECON), INSPEC Accession Number: 8371331, Digital Object Identifier: 10.1109/SAHCN.2004.1381935, October, 2004, Santa Clara, CA. (Acceptance rate: **18%**) pp. 342-351.
 69. Ruhyyih Mahalati, Rudra Dutta, "Reconfiguration of Traffic Grooming Optical Networks", Proceedings of BroadNets 2004, INSPEC Accession Number: 8331755, Digital Object Identifier: 10.1109/BROADNETS.2004.72, ISBN 0-7695-2221-1, October, 2004, San Jose, CA. (Acceptance rate: 30%) pp. 170-179.
 70. Bensong Chen, George Rouskas, Rudra Dutta, "Traffic Grooming in WDM Ring Networks with the Min-Max Objective", in Proceedings of Networking 2004, LNCS Vol. 3042, pp. 174-185, ISBN: 3-540-21959-5, May, 2004, Athens, Greece. (Acceptance rate: **19%**)
 71. Rudra Dutta, Shu Huang, George Rouskas, "On Optimal Traffic Grooming in Elemental Network Topologies", in Proceedings of Opticomm 2003, pp. 13-24, SPIE, Vol. 5285, ISBN: 0-8194-5180-0, October 13-17, 2003. (Acceptance rate: 37%)
 72. Rudra Dutta, Shu Huang, George Rouskas, "Traffic Grooming in Path, Star and Tree Networks: Complexity, Bounds, and Algorithms", Proceedings of ACM SIGMETRICS, International Conference on Measurement and Modeling of Computer Systems, June, 2003, San Diego, CA, pp 298 – 299, ISBN:1-58113-664-1. (Acceptance rate: **18%**) [Also: ACM SIGMETRICS Performance Evaluation Review, Volume 31, Issue 1, June 2003].
 73. Rudra Dutta, George Rouskas, "On Optimal Traffic Grooming in WDM Rings", Proceedings of ACM SIGMETRICS/PERFORMANCE 2001, International Conference on Measurement and Modeling of Computer Systems, pp. 164-174, June 16-20, 2001, Cambridge, MA, ISBN:1-58113-334-0. (Acceptance rate: **12%**) [Also: ACM SIGMETRICS Performance Evaluation Review, Volume 29, Issue 1, June, 2001].
- **Invited Papers (Not Peer-Reviewed)**
 1. George Rouskas, Ilia Baldine, Rudra Dutta, "A New Internet Architecture to Enable Software Defined Optics and Evolving Optical Switching Models", in Proceedings of BroadNets, 2008, pp. 71-76, IEEE Xplore DOI: 10.1109/BROADNETS.2008.4769046.
 2. Mohan Iyer, George N. Rouskas, Rudra Dutta, "Hierarchical Grooming in Multigranular Networks", in Proceedings of the Advanced Networks and Telecom Systems Conference, December, 2007.
 3. Rudra Dutta, George Rouskas, "Bounds on Traffic Grooming in Star and Tree Networks", in Proceedings of the 39th Allerton Conference on Communication, Control and Computing, October 3-5, 2001, Monticello, Illinois.

4. Rudra Dutta, George Rouskas, "Topology Design in WDM Rings to Minimize Electronic Routing: Efficient Computation of Tight Bounds", in Proceedings of the 38th Allerton Conference on Communication, Control and Computing, pp 1284-1293, October 4-6, 2000, Monticello, Illinois.
- **Workshop Papers (Peer-Reviewed)**
 1. Takaya Miyazawa, Hiroaki Harai, Robinson Udechukwu, Rudra Dutta, "Experimental Demonstration of Interconnection Between ChoiceNet Economy Plane and Optical Packet and Circuit Integrated Network Control Plane", in IEEE High Performance Switching and Routing Workshop (HPSR) workshop, 2016.
 2. Shireesh Bhat, Robinson Udechukwu, Rudra Dutta, George Rouskas, "Inception to application: A GENI based prototype of an open Marketplace for network services", in IEEE Conference on Computer Communications Workshops (INFOCOM-WKSHPS), April, 2016, pages 1043-1044.
 3. Magreth Mushi, Rudra Dutta, "Data-driven Study of Network Administration in the Evolving Landscape of Software Defined Networking", in Proceedings of LAS Workshop on Human-Centered Big Data Research, April, 2014 (published through ACM Digital Library)
 4. Ahmet C Babaoglu, Rudra Dutta, "A GENI Meso-Scale Experiment of a Verification Service", in Proceedings of the 3rd GENI Research and Educational Experiment Workshop (GREE2014), Atlanta, GA, USA, March 19-20, 2014.
 5. Umang Patel, Trisha Biswas, Rudra Dutta, "A Routing Approach to Jamming Mitigation in Wireless Multihop Networks", in Proceedings of IEEE LANMAN, 2011, Oct 2011, Chapel Hill, NC, pp 1-6, ISBN: 978-1-4577-1264-7, doi: 10.1109/LANMAN.2011.6076932, IEEE.
 6. Shu Huang, Rudra Dutta, "Research Problems in Dynamic Traffic Grooming in Optical Networks", in Proceedings of the First International Workshop on Traffic Grooming, October, 2004, San Jose, CA. (CD-ROM publication – No page numbers)
 7. Bensong Chen, Rudra Dutta, George Rouskas, "Traffic Grooming in Star Networks", in Proceedings of the First International Workshop on Traffic Grooming, October, 2004, San Jose, CA. (CD-ROM publication – No page numbers)

Poster Presentations

- **Peer-Reviewed**
 1. Mihail Sichitiu, Rudra Dutta, "Benefits of Multiple Battery Levels for the Lifetime of Large Wireless Sensor Networks", at Networking 2005, May, 2005, Waterloo, Canada.
 2. Rudra Dutta, Shu Huang, George Rouskas, "Traffic Grooming in Path, Star and Tree Networks: Complexity, Bounds, and Algorithms", at ACM SIGMETRICS, June, 2003, San Diego, CA.
- **Not Peer-Reviewed**
 1. Rudra Dutta, Pritesh Patwa, Dheeraj Kandula, "Modeling Feedback Effects in Vehicular Networks", at the First INTRsection Automotive Industry Workshop, Raleigh, March 2006.
 2. Mihail Sichitiu, Maria Kihl, Rudra Dutta, "Inter-Vehicle Communication System Applications", at the First INTRsection Automotive Industry Workshop, Raleigh, March 2006.

Invited Talks (Not Peer-Reviewed)

1. Rudra Dutta, "Internet Architecture: the Role of Economy and Choice in the Services Internet", at Indian Statistical Institute, Kolkata, India, July, 2014.
2. Rudra Dutta, "Future Internet Design and the Role of Choice", at SAS Institute, RTP, NC, April, 2012.
3. Rudra Dutta, "Network Planning Problems in Optical and Wireless Networks", at the Department of Electrical Engineering and Computer Science, University of Texas and Dallas, November, 2005.

News Mentions

1. Phys.org published an article reviewing what Google Fiber may mean for the Triangle region and NC State in particular, in which they interviewed Dr. Dutta, and Dr. Marc Hoit (OIT Chief) in January 2015. The article may be found at <https://phys.org/news/2015-01-google-fiber-north-carolina-nc.html>.
2. The local newspaper *The News and Observer* covered the First NCSU CentMesh Drones Challenge, organized by Dr. Dutta and Dr. Mihail Sichitiu, on April 13th, 2014. More details about the challenge can be found at http://go.ncsu.edu/drones_challenge_2014.
3. Phys.org published an article on Dr. Dutta's research on flexible channel width in June, 2012. The article may be found at <https://phys.org/news/2012-06-flexible-channel-width-user-wireless.html>.
4. Zdnet.com published an article on Dr. Dutta's research on centrality-based power control for mesh wireless networks on April 19, 2012. The article may be found at <http://www.zdnet.com/article/new-technique-boosts-efficiency-of-multi-hop-wireless-networks/>.

5. National Public Radio (WUNC) in November, 2011, on the “All Things Considered” program, covered the ChoiceNet project funded by an NSF grant, including quotes from Dr. Dutta and other PIs from NCSU and UNC-CH

III. B. Research Projects

The table below summarizes research project funding. The following tables provide detailed listings of each category.

Pending:	None
Current:	\$292K external
Past:	\$6298K external \$138K internal \$56K Gift in kind \$50K Gift in cash

Currently Active:

Title	Source	PI(s)	Start Date	End Date	Amount	Notes
NeTS: JUNO: Service Offering Model and Versatile Network Resource Grooming for Optical Packet and Circuit Integrated Networks	NSF	Rudra Dutta	April 2014	September 2018	\$291,955	

Past:

Title	Source	PI(s)	Start Date	End Date	Amount	Notes
CC-NIE Networking Infrastructure: Data Intensive e-Science and SDN at NCSU	NSF	Marc Hoit, Rudra Dutta, Greg Sparks, Will Brockelsby	August 2013	July 2016	\$499,890	
Studying Latency and Stability of Closed Loop Sensing Based Security Systems	NSA	Rudra Dutta, Meeko Oishi (UNM)	May 2012	May 2013; extended: May 2014	\$172,222	Includes UNM subcontract – NCSU total is \$109,074
NeTS: Large: Collaborative Research: Network Innovation Through Choice	NSF	Rudra Dutta, George Rouskas	Sep 2011	Aug 2014 (extended : Aug 2016)	\$643,917	NCSU budget only – total is \$2.7 M
Secure Open Systems Initiative	ARO	Dennis Kekas, Mladen Vouk, Peng Ning, Rudra Dutta	Mar 2008	November, 2014 (extended: November, 2015)	\$3,347,000	Includes second year supplement
Quantifying Underpinnings for Network Analytics as Components of	NSA	Rudra Dutta	Jan 2012	Dec 2012	\$81,946	

Composable Security						
CSC NetLab virtualization and expansion equipment	NCSU COE	Rudra Dutta	Jan 2011	Sep 2012	\$130,000	Internal One-time ETF funding
GENI IMF: Integrated Measurement Framework and Tools for Cross Layer Experimentation	GENI Project Office	Rudra Dutta, George Rouskas	Jan, 2010	Sep 2012	\$419,506	Includes subcontracts – NCSU total is \$143,506
Pronto 3290 OpenFlow switches	GENI Project Office	Rudra Dutta, Ilia Baldine (RENCI), Don Smith (UNC-CH), Jeff Chase (Duke)	Mar 2010		\$15,000	Gift in kind NCSU budget (1 switch) only – total is five switches
80 Moto Droid phones	Google	Rudra Dutta	Mar 2010		\$34,800	Gift in kind (value as stated in Google's award letter – retail value was \$45K)
Centennial Outdoor Wireless Mesh Network Testbed for Research and Education (CentMesh)	ARO	Rudra Dutta, Mihail Sichitiu	Jul 2009	Dec 2011	\$149,000	Defense University Research Instrumentation Program Period includes no-cost extensions
Collaborative Research: NeTS-FIND: The SILO Architecture for Services Integration, control, and Optimization for the Future Internet	NSF	George Rouskas, Rudra Dutta	Sep 2006	Feb 2010	\$228,000	Includes \$8K REU supplement
Developing a Telematics Platform for Bridge Monitoring and Health Prognostics (funded as supplement to "Research Site of the I/UCRC entitled Repair of Building and Bridges with Composites")	NSF	Sami Rizkalla, Rudra Dutta, Mihail Sichitiu	Sep 2006	Feb 2008	\$112,000	Amount of specific supplement only; total is 412,000
Unrestricted Gift	Microsoft	George Rouskas, Rudra Dutta	Mar 2006		\$50,000	Gift in cash
A Formal Approach to Traffic Grooming in Optical Networks with General Topologies	NSF	George Rouskas, Rudra Dutta, Carla Savage	Oct 2003	Sep 2007	\$405,000	
30 iMotes	Intel	Rudra Dutta	Oct 2005		\$6,000	Gift in kind
Cognitive Wireless Mesh	CACC	Mihail	Apr 2006	Dec 2007	\$40,000	

Networks		Sichitiu, Rudra Dutta, Phil Emer				
NCSU TIE: Wireless Sensor Networks for Structural Health Monitoring of Buildings	NSF	Dennis Kekas, Mihail Sichitiu, Rudra Dutta	Sep 2003	Dec 2005	\$200,000	Period includes no-cost extension
Traffic Grooming in Wavelength Routed Networks with Novel Topologies	FR&PD, NCSU	Rudra Dutta	Mar 2003	Feb 2004	\$8,000	Internal

Travel Grants:

- Received travel grant from NSF for my student Shu Huang to travel to Opticomm, 2003, enabling him to hear papers presented and meet outstanding researchers of his research area. The grant paid for conference registration, travel, and a part of accommodation, value about \$1000.
- Received travel grant from NSF for my student Bensong Chen to travel to BroadNets, 2004, enabling him to hear papers presented and meet outstanding researchers of his research area. The grant paid conference related costs not exceeding \$1200.

Cross-disciplinary Activities

- Participating in a university-level effort to form a multi-organization team to respond for NSF's Platform for Advanced Wireless Research grant solicitation, for an estimated \$20M grant.
- Participated in a university-level effort to assist the City of Raleigh in responding to a SmartCity challenge from the US DoT. Although our team did not place within the 7 finalists, this forged an important working relationship with the city, which has been acknowledged by the Chancellor in a letter.
- Coordinated a university-level effort to respond to the NSF Data and Networking Infrastructure (CC*DNI) solicitation to submit a \$5M grant proposal (pending), with many PIs and senior personnel from NCSU Office of Information Technology, NCSU Institute of Transportation Research and Education, UNC Chapel Hill Highway Safety Research Center, and the Research Triangle Institute, proposing a novel regional research enablement facility for transportation research, in collaboration with NC Department of Transportation.
- Led a university-level effort to respond to the NSF Campus Cyberinfrastructure - Network Infrastructure and Engineering (CC-NIE) solicitation to submit a large infrastructure grant proposal, with PIs from NCSU Office of Information Technology, CommTech, and Computer Science, and involving interaction with more than 20 NCSU faculty from various departments, 12 building facilities, and proposing a novel flexible campus network infrastructure. On second attempt, this proposal was funded – see above.
- Led a cross-disciplinary proposal team, consisting of faculty from Civil, Construction, and Environmental Engineering, Electrical and Computer Engineering, and Computer Science, to submit a large grant proposal (pending) in response to the Cyber-Physical Systems solicitation from NSF.
- Served on Dean's Task Force for inaugural Engineering Day constructed project, 2009
- Serving as Associate Technical Director of Secure Open Systems Initiative
- Participation in Reinforced Building and Bridges with Composites Center (an NSF-sponsored I/UCRC) – currently listed as a PI (involvement was in obtaining supplement)
- Active in research collaboration with Civil Engineering faculty from NCSU and University of Delaware (see projects above)
- Participant in Institute for Technology of the Next Generation (ITng)
- Attended Automotive workshop at College of Textiles, prepared and presented four invited posters, three of own research and one on behalf of networking group

IV. Extension and Engagement with Constituencies outside the University

IV. A. Accomplishments

GENI:

The Global Environment for Networking Innovation (GENI) is an initiative funded by NSF to provide a national resource to networking and computing researchers and educators. It is intended to be a virtual laboratory in which a wide variety of networking experiments can be performed, at national scale, by many research groups in parallel. As such, this testbed attempts to provide the capability to “slice”, or virtualize, all resources in the entire GENI network. This is a tremendous challenge by itself, considering the national footprint of GENI. It is all the more complicated because the various resources in the GENI substrate are typically innovative and non-standard networking equipment in themselves – such as a sensor testbed in Oklahoma or a low-altitude radar network in Massachusetts – and also under different ownership and management. These diverse resources as well as the available national bandwidth has to be “slivered”, and then “stitched”, to provide a seamless “slice” for a researcher – a network with national footprint made of real equipment but isolated from the networks of other GENI users. More information can be found at <http://www.geni.net>.

IEEE ANTS:

The IEEE International Conference on Advanced Networking and Telecommunications Systems (ANTS) is now in its sixth year, and Dr. Dutta has been involved in its organization from the very beginning. He was one of the small team of people who were involved in creating this conference, centered on telecommunications issues in growing highly populous economies such as many of South-east Asia, and the first IEEE networking conference to be homed in India, one of the largest and fastest growing networking industry arenas in South-east Asia. Dr. Dutta has served the conference in various organizing roles, including TPC Chair and General Chair, and on the steering committee for the last two years.

Local engagement:

Dr. Dutta also engaged with various industrial and educational entities outside the university to serve the overall mission of the university. His recent Future Internet Architecture grant from NSF attracted some public attention – he was interviewed by WUNC (local station of National Public Radio), who subsequently aired a story on his project for several successive days in November, 2011, on their “All Things Considered” program, including quotes from Dr. Dutta and other PIs from NCSU and UNC-CH. SAS Institute invited Dr. Dutta to deliver a talk at its “BIRD's Eye View” seminar series on this and other topics of his research, and he delivered the talk in April, 2012. It was attended locally by about 50 people and by several more remotely. SAS has retained the archived video of that talk for later viewing by employees (it is also publicly accessible – linked from his website).

Dr. Dutta mentored a group of three seniors from a local high school during Summer 2013 for a project that they submitted to the Siemens competition, and later the Intel science competition. The project was to design, realize and demonstrate a simultaneous localization and mapping application based on Android devices, by tracking footfalls of users. They reached to the regional level of the Siemens competition (the first time anybody had done so from their high school), and reached the final level as well as claimed a prize (the GoDaddy prize for best mobile app) at the Intel competition.

In Summer 2015, Dr. Dutta acted as mentor for one of the four undergraduate students visiting under the Palestine Technical University undergraduate research extension program. The student worked on research in the design and usability of network equipment administration interfaces.

IV. B. Program Impacts

GENI:

Participation in GENI as a funded project has tremendous impact for Dr. Dutta, and for NCSU, in the national context. To build this unprecedented facility, NSF funded BBN to set up the GENI Project Office, which in turn funded researcher groups to architect and develop parts of the whole. The project of which Dr. Dutta is the PI is the only one at NCSU that has been funded by GENI. Building GENI is an engineering exercise, but one that demands that experience and awareness in breadth of networking research inform it at every point. It is thus doubly challenging for an academic, in having a broad understanding of active research, in being able to work with researchers and research students, but

follow the processes and standards of deliverables that are more typical of production-grade engineering. Dr. Dutta has risen to the challenge and well met it, to earn the respect of a community. In the third and last year, his project designed and contributed the Measurement Plane messaging system for the instrumentation and measurement cluster of GENI. This is currently forming a critical piece of *both* GEMINI and GIMI – the two redundant Instrumentation and Measurement architectures being developed for GENI (Dr. Dutta is part of the GIMI effort).

Dr. Dutta has also taken a leading role in utilizing GENI for enriching instruction. He has taught the *Internet Protocols* graduate level course at NCSU multiple times with students performing lab exercises and projects on GENI. His recent administration of this course with a class of 86 graduate students is the largest that anybody has ever attempted to use GENI as part of regular teaching. Dr. Dutta was invited by the GENI Project Office to serve on a panel on “GENI in Education” and give a talk on the topic at the recent 22nd GENI Engineering Conference, in March, 2015.

IEEE ANTS:

IEEE ANTS has high visibility and impact due to the pioneer nature of the academic-industry meeting place it represents, in an emerging new technology context. The distinguishing characteristic of IEEE ANTS is the promotion of an intense dialogue between academia and industry to bridge the gap between academic research, industry initiatives and governmental policies. Starting its second year, ANTS was recognized by IEEE Communications Society not only as being a sponsored conference, but a “portfolio conference”, one of only three region-centered conferences in the ComSoc portfolio (<http://www.comsoc.org/conferences/portfolio-events>).

V. Technological and Managerial Innovation

V. A. Knowledge and Technology Transfer Accomplishments

CentMesh:

In Spring 2012, an effort Dr. Dutta has been leading for several years completed the final phase, and the Centennial Wireless Mesh Testbed (CentMesh) has been built and deployed for use by NCSU researchers and instructors. CentMesh is an outdoor, highly programmable, extensible, open testbed to support research and education on the design of wireless mesh networks, as well as IT systems and applications enabled by wireless mesh networks. The testbed was part of the vision included in the Secure Open Systems Initiative (SOSI) of which Dr. Dutta is a PI, and subsequently, in 2009, he was also awarded Defense University Research Instrumentation Program (DURIP) funding from the Army Research Office to significantly increase the scope of this testbed.

CentMesh is a highly realistic outdoor testbed, consisting of 14 permanent nodes and 8 mobile pushcart-mounted nodes. Wireless and mobile devices have been increasingly making up the untethered edge of the planetary network. Research in various wireless networking problem areas are among the most exciting research areas in computing at this time. It is also an attractive topic for students – a welcome opportunity at a time when there is an urgent need to rethink the teaching of computing topics, including networking and network design, which have the potential to excite and interest students.

However, wireless is also a less controlled environment, and thus research in wireless networking is unlikely to be realistic, or have real-world relevance, if it is conducted entirely on paper, and not proved on a real environment. The same is true of research in other areas of computer science that are enabled by wireless networks: applications or cyber-physical systems residing on top of wireless networks or having wireless system constituents. Many emerging security and network research questions are in areas of network availability, reliability etc. Solutions are often proposed in research through routing, opportunistic MAC, adaptive power control, dynamic rate control and modulation, and other such research areas; these are all low down, or across traditional boundaries of, the networking stack.

Commercially available wireless networking equipment does not allow experimentation at these detailed levels, and researchers are reduced to using commodity computing hardware and using them as wireless equipment. While this approach serves in the short term, it means that every small change in the protocols that the researcher wants to investigate require painstaking changes of the entire networking kernel. This is especially true when the researcher is operating across multiple layers. Or the research might be a cross-layer control area, where wireless networking forms only an enabling part of the innovation, the other part – more primary to the researcher – may not be directly related to networking at all. Such a researcher is unlikely to engage in the tedious reprogramming of the Linux kernel required.

Dr. Dutta envisioned CentMesh, and subsequently architected and developed it, to provide a versatile wireless networking substrate that would be deeply programmable (to allow whatever research innovation it was called upon to support), but provide a flexible and modular interface (to allow a researcher to make specific changes in the programming relevant to the research without requiring to undertake a large software project). Further, it would be architected to be extensible; the basis of ever more ambitious and powerful research enabling infrastructures to come, as researchers pursue evolving research directions, both guiding and contributing to the enhancement of CentMesh capabilities. Near future plans include adding dynamic spectrum access, MIMO, and similar capabilities to CentMesh.

Since Spring 2015, Dr. Dutta has started an effort to resurrect the defunct Wisenet wireless networking research testbed (originally created by Drs. Rhee and Ning, in 2007), to serve as a versatile teaching testbed for Cyber-physical System and Internet of Things topics. Several graduate students and an undergraduate research (CSC499) student have worked over the past few semesters with Dr. Dutta to design, deploy, and test this facility. It is currently operational with a small initial deployment of 10 nodes. By the end of summer, the web-based scheduling and access control interface is expected to be operational, leading to teaching use of this this facility in Fall 2016. It has already been used by a research student as a testbed on a pilot research project, and is planned to be made available to students for term projects for the CSC453 course taught by Dr. Dutta, an undergraduate course on the Internet of Things.

V. B. Program Impacts

As of Spring, 2012, the previously mentioned visions were fulfilled and CentMesh has been online since that time. Since its very inception in late 2008, Dr. Dutta has led this effort, which has required not only innovative software

design for the CentMesh platform, but very significant effort in collaboration and interaction with many offices and authorities within NCSU. The installation and operation of CentMesh is being handled by NCSU OSCAR Labs, and coordinated with CommTech. Dr. Dutta continues to serve as the main technical contact point for ongoing coordination, as well as innovative opportunities. These take the form of ongoing weekly meetings with the entire CentMesh team to track the status of the facility, and ad-hoc meetings and discussions with researchers in and outside NCSU to follow up on opportunities of collaboration. As examples, the team is embarking on a project on intelligent transportation in collaboration with NCSU's Institute for Transportation Research and Education, and on another on smart environmental sensing in collaboration with faculty from the Civil, Construction and Environmental Engineering department.

Supporting the teaching mission of NCSU faculty by providing a laboratory environment continues to be one of the primary purposes of the infrastructure. It is widely accepted that a hands-on complement to lectures is distinctly helpful in engaging the attention and interest of the student, and results in better retention as well. Dr. Dutta is actively following this goal; in Spring, 2012, he co-taught a seminar course with Dr. Sarah Heckman, a Teaching Assistant Professor of his department, to guide interested senior graduate students in developing laboratory exercises to support teaching in undergraduate and graduate networking courses. In Fall, 2012, he taught a senior level undergraduate course in sensor networking which utilized sensing code developed in CentMesh as a laboratory project, and in Spring, 2013, he is teaching a graduate level seminar course supported by his Software Defined Laboratory project.

Over 2013-14, Dr. Dutta, together with Dr. Mihail Sichiitu of the ECE department, conceived and hosted a student programming contest on the *CentMesh Drones* – a programming challenge in which the programming platform was a Linux computer mounted on and flying an unmanned aerial vehicle, integrated with CentMesh. The Fall, 2013 semester consisted of planning and prototyping the programming platform, and creating tutorial material for the platform fabricated. The student challenge ran over Spring of 2014, culminating in a grand challenge on April 12th, 2014, at which the qualifying teams from the initial rounds of the challenge pitted their programs against each other, trying to meet challenges such as flying an obstacle course with dynamically specified 3-D obstacles. The event generated a very large amount of student interest and engagement, and was covered by the local newspaper *The News and Observer* the next day. More details about the challenge can be found at http://go.ncsu.edu/drones_challenge_2014.

Over 2014-15 and 2015-16, Dr. Dutta spearheaded a new drones challenge. This effort also includes Dr. Mihail Sichiitu of the ECE department, and Dr. Larry Silverberg of the MAE department. The effort has been structured as special topic courses in Fall 2014 and Spring 2015. Students have been challenged on build on the existing expertise gained in the CentMesh project and the First NCSU Centmesh Drones challenge – to design, build, and prove a drone capable of being flown indoors by inexperienced operators, while intelligently avoiding obstacles, sensing heat and flames, and locating survivors in a building on fire: the firefighter's drone challenge. Final trials will be held in early May 2015. Ongoing information about the challenge can be found at http://go.ncsu.edu/drones_challenge.

Since Spring, 2016, Drs. Dutta, Silverberg, and Sichiitu have been working at creating a Study-Abroad program for NCSU students in which they will travel to Namibia, and participate in the deployment of drone technology to assist parks and game conservationists in managing protected wildlife, and fighting poachers. This study aboard program has been launched and will be available to students in AY 2018-19; it is currently listed for multiple departments including Computer Science although current course availabilities allow only MAE students to take it. Dr. Dutta is working on making appropriate course credits available to enable CSC students to take advantage of this.

VI. Service to the University and Professional Societies

University Service:

- Member, University Standing Committee on Extension, Engagement, and Economic Development, 2017-18, 2016-17.
- Mentor, University Mentor-Rings program, 2017-18, 2016-17.
- Mentor, Inaugural University Mentor-Rings program, Spring 2016.
- Member, Strategic Planning Committee, CSC Dept, 2015-16, 2014-15.
- Member, Graduate Program Oversight Committee, CSC Dept, 2016-17, 2015-16, 2014-15, 2013-14, 2012-13, 2011-12, 2010-11.
- Chair of the Graduate Admissions Committee, Computer Science Department, 2009-10, 2008-09, 2007-08.
- Chair of the Committee on Committees, Computer Science Department, Fall, 2007 - Spring 2008.
- Member of the Committee on Committees, Computer Science Department, Fall, 2006 - Spring 2007.
- Member of the Committee on Minority Recruitment, Computer Science Department, Fall, 2006 - Spring 2007.
- Member of the IT Services Initiative Committee of the Computer Science Department since Spring, 2006.
- Member of the Undergraduate Curriculum Committee of the Computer Science Department since Fall 2001 to Fall, 2005.
- Member of the working group to develop Program Objective, Outcome and Assessment for the Computer Science Department.
- CSC departmental representative at the College of Engineering Course and Curriculum Committee, Spring, 2003.
- Meeting visiting prospective graduate students, Spring, 2002, Spring, 2003, Spring, 2004, Spring 2005, Spring 2010.
- COE Open House participant every year since 2001-02.

Professional Community:

- TPC Co-Chair, IEEE Sarnoff Symposium, 2017
- TPC Co-Chair, IEEE NFV/SDN 2017
- TPC Co-Chair, IEEE Sarnoff Symposium, 2016
- Secretary, IEEE NFV/SDN 2016
- Tutorials Co-Chair, Sarnoff Symposium, 2015
- International Publicity Chair, IEEE Advanced Networking and Telecommunications Conference, 2013, 2012, 2015
- Technical Program Committee Co-Chair, Design of Reliable Communications Networks, 2015
- Steering committee member, IEEE Advanced Networking and Telecommunications Conference, 2013, 2012, 2011
- Guest Editor, Elsevier OSN, Special Issue on ANTS 2011
- Guest Editor, Elsevier OSN, Special Issue on ANTS 2010
- Editor, Elsevier Journal of Optical Switching and Networking
- Editor, Springer Journal on Photonic Network Communications
- General Chair, IEEE Advanced Networking and Telecommunication System (ANTS) 2010
- Guest Editor, Elsevier OSN, Special Issue on Green Communication Networks
- Guest Editor, Elsevier OSN, Special Issue on ANTS 2009
- Program Chair, IEEE Advanced Networking and Telecommunication System (ANTS) 2009
- Program Chair, Optical Networking Symposium, IEEE Globecom, 2008
- Program Vice-Chair, Optical Symposium, IEEE International Conference on Communication (ICC) 2008
- Grant proposal review panelist, US National Science Foundation (2005, 2008, 2012, 2014, 2016)
- Grant proposal review panelist, US Department of Energy (2009)
- Grant proposal reviewer, Canadian Natural Sciences and Engineering Research Council (2011)
- Grant proposal reviewer, US Army Research Office (2012, 2013)
- Organizing Committee member, BroadNets 2007 (IEEE sponsored conference) – Industrial Liaison and Sponsorship Chair

- Organizing Committee member (Panels Chair) and Technical Program Committee member, BroadNets 2006 (IEEE sponsored conference)
- Organizing Committee member (Panels Chair) and Technical Program Committee member, BroadNets 2005 (IEEE sponsored conference)
- Co-Chair, 2nd International Workshop on Traffic Grooming, 2005 (IEEE sponsored)
- Technical Program Committee member, 1st International Workshop on Traffic Grooming, 2004 (IEEE sponsored)
- Member, International Federation for Information Processing (IFIP) Working Group 6.10 (Photonic Networking)
- Member, IEEE, IEEE Communications Society
- Member, Association for Computing Machinery
- Technical Program Committee member and reviewer of numerous high-quality conferences, including IEEE Infocom, ICC, Globecom, ICCCN, ANTS, SECON
- Reviewer for many premium journals, including IEEE/ACM Transactions on Networking, IEEE Journal on Selected Areas in Communications, IEEE Transactions on Computers, IEEE Communications Letters, Elsevier Journal of Optical Switching and Networking, Elsevier Computer Networking