C^2M^2 NEWS

In this issue:

Letter from the Director

Welcome to our very first USDOT Center for Connected Multimodal Moblility (C^2M^2) newsletter. We are extremely honored to have been granted a Tier 1 University Transportation Center by the United States Department of Transportation, which will be headquartered at Clemson University. We are delighted to showcase the efforts of our multi-disciplinary, multi-campus collaboration. We are excited about the months and years to come as our vision for our center transforms from proposal to reality.

Smart cities prosper because their diverse infrastructures are connected to provide required services in a sustainable, secure, reliable, and efficient fashion. To create the smart transportation network of the future, C^2M^2 brings together five institutions of higher learning from across the state of South Carolina to improve connectivity between vehicles and other vehicles (V2V communication) and vehicles and infrastructure (V2I communication). The aim is to create a

Dr. Mashrur "Ronnie" Chowdhury

seamless network connecting transportation system users and service providers such as state departments of transportation or transportation network companies.

Such connectivity promises broad benefits in terms of safety, mobility, environmental sustainability, equity, and much else. For example, connected vehicles and infrastructure may warn motorists or autonomous vehicles of impending collisions, thus saving money, and, more importantly, lives.

Smart intersections that communicate with approaching vehicles may dramatically reduce traffic signal delay, with benefits for travelers and the environment. V2V may permit dense "platoons" of vehicles on our highways, allowing them to travel safely in close proximity to each other and at high speeds, increasing functional roadway capacity and reducing travel times and congestion.

> "Emerging connected and automated vehicle technologies are the future of multimodal mobility—a future of interconnections of information systems in ways never previously imagined."
>
> *-Dr. Ronnie Chowdhury*

V2V and V2I communication may allow the collection and dissemination of information about traffic, road closures, construction work, dangerous road conditions, crashes, and more. These data may be communicated to motorists to allow faster, safer, and more environmentally friendly travel, and to transportation agencies to permit faster response times when problems such as crashes or vehicle disablements occur. V2I may also provide better data on infrastructure use for transportation planning and engineering agencies, and much else.

Moving people and goods reliably, efficiently, and safely in a connected world involves collecting, processing, distributing, and archiving a large amount of data securely and within time constraints. Also, the different modes of transportation require sophisticated synchronization, enabled by real-time data communication, to provide more flexible and customized services, greater reliability, and robust resilience. Our goal is to become an innovative and globally

recognized innovation center that finds solutions to these problems.

USDOT and C²M² representatives at the kick-off meeting.   Photo credit: Sandy Priddy

C^2M^2 is the first USDOT Tier 1 University Transportation Center in South Carolina. As such, it will have myriad benefits for the state. It will foster collaboration between numerous stakeholders, including the universities participating in the center, government agencies which manage one of the most diverse transportation systems in the nation (including road, rail, air and seaborne transportation), and the private sector firms which have made the state one of the nation's leading transportation manufacturing hubs for everything from aircraft to electric buses.

Working with these partners, C^2M^2 will conduct and disseminate research to show how V2V and V2I can optimize the functioning of the state's transportation system. For example, it will help create and manage innovative testbeds in South Carolina for developing and testing V2V and V2I technologies. In addition C^2M^2 is focusing on improving autonomous vehicle safety and operations through V2V and V2I technologies.

PhD student Sakib Khan helping STI students plan their communication systems.
Photo credit: Benny Brown

C^2M^2 will conduct workforce development programs to ensure the state has the skilled workers to confront today's transportation challenges, as well as educational programs to train the transportation workers of tomorrow. Its special focus will be on historically underserved populations to ensure equitable access to the benefits offered by the transportation sector.

And while C^2M^2 will pay special attention to the local issues, the impacts of its research activities will be global; we aim to be one of the leaders in research into cutting-edge connectivity technologies that will benefit the state, nation, and world.

Dr. Mashrur "Ronnie" Chowdhury
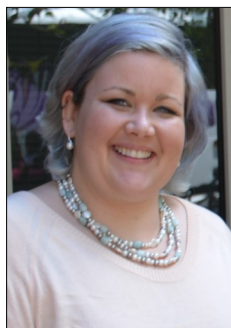
INTRODUCING OUR PROGRAM COORDINATOR

One of C^2M^2 first official actions was to hire a program coordinator to oversee the center's activities, handle communications, and to assist the director and associate directors. Charlotte Ryggs was selected from over 30 candidates to fill this role. Charlotte comes from an education/hospitality background, and has experience teaching, event planning, serving as an administrative assistant, and managing guest services. She is a Furman University graduate originally from Kalamazoo, Michigan, and she now lives in Greenville, South Carolina.

Photo credit: Bennie Brown

MEET OUR ASSOCIATE DIRECTORS

C^{2}M^2 has the support of a team of prestigious professors from our partner institutions acting as our associate directors. They will be involved in all aspects of the Center's research, education, training, and technology transfer missions. Our associate directors specialize in a variety of fields and each brings a unique vison and knowledge base to our center. Our team has expertise in multimodal transportation systems design, analysis and performance evaluation, emerging transportation demand and supply patterns, connected transportation systems, and the Internet of Things, which entails using sensors to collect data from, and provide it to, almost any vehicle, infrastructure component, or transportation service provider.

Dr. Gurcan Comert joins us from Benedict College, which is a historically black liberal arts college located in Columbia, South Carolina. He teaches both physics and engineering. Dr. Comert specializes in intelligent transportation systems, statistical modeling, and connected vehicles and signal operations.

Dr. Dimitra Michalaka is an Assistant Professor at the Citadel, where she teaches in the Civil and Environmental Engineering department. Dr. Michalaka's research focuses are traffic operations, congestion pricing, traffic simulation, and engineering education.
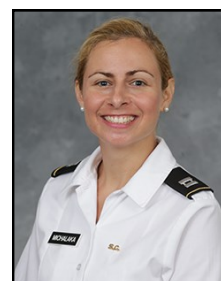
Dr. Judith Mwakalonge teaches at South Carolina State University, a historically black university, in the Department of Civil & Mechanical Engineering Technology & Nuclear Engineering. Dr. Mwakalonge's areas of expertise are travel demand modeling, model transferability, traffic simulation, pedestrian traffic, and engineering education.

Dr. Nathan Huynh is an Associate Professor at the University of South Carolina, in the Civil and Environmental Engineering Department. His research focuses are supply chains and logistics, intermodal network design, freight transportation systems, and civil infrastructure systems.

C^{2}M^2 SUMMER CAMP FUN

Last month we were delighted to host students from Benedict College's Summer Transportation Institute (STI) for a day of fun and learning in Columbia at the University of South Carolina (USC) and a day in our lab at Clemson University. The STI is a scholarship-based residential camp for rising 9th, 10th, and 11th grade students interested in the transportation industry. STI is sponsored by the Federal Highway Administration and the South Carolina Department of Transportation (SCDOT) and takes place on the campus at Benedict College.

PhD Student Mhafuzul Islam explaining the technology in a connected vehicle to students from Benedict College's Summer Transportation Institute.

Dr. Chowdhury explaining the future of Connected Autonomous Vehicles to STI students.

During the four week program these students learned about all aspects of the transportation industry through a combination of site visits, speakers, and classroom activities.

C^2M^2's first visit with the students from STI took place in Columbia where they were introduced to various engineering majors and learned about admission requirements for USC. After this overview, several USC engineering professors, led by Dr. Nathan Huynh, took turns speaking about the research that they were currently working on, giving the students a chance to ask specific questions about the different type of projects happening at USC. After the presentations the students were taken to the SCDOT District 1 Office where they were given a tour of the Transportation Management Center and the signal shop, and an opportunity to ask questions of various SCDOT employees.

Contest winners with C^2M^2 representatives
L-R C. Ryggs, V. Douglas, R. Morris, M. Green, M. Chowdhury
Photo credit: Benny Brown

STI students at USC learning about various transportation engineering majors from Dr. Huynh.

STI's visit to Clemson took place in the Engineering Innovation Building, and kicked off with a presentation on Connected Autonomous Vehicles by Dr. Chowdhury. After Dr. Chowdhury's talk, the students were split into two groups, with one group going to the Transportation Cyber-Physical Systems Lab to learn about programing connected traffic signals, while the other group saw a live demonstration of connected vehicles, learning about the equipment necessary for data collection. These groups then switched places so that everyone could get some hands-on learning before returning to the classroom for a lesson on Wireless Communication Systems. After lunch the students' knowledge was tested with a competition to see if they could create their own wireless communication systems for Intelligent Transportation Systems using what they had learned that morning. At the afternoon's end, the campers turned in their systems and the three best were awarded certificates and a prize.

UPCOMING RESEARCH

In June of 2017 C^2M^2 sent out a Call for Proposals (CFP) for our first round of research funding. This CFP was sent out to C^2M^2 faculty members in relevant fields at all five of the consortium's universities. The center received 16 proposals covering a wide array of topics, featuring proposed research on V2V and V2I data infrastructure, pedestrian safety, transportation cyber security, and ride sharing, among much else. Many of these proposals feature collaborative research among multiple universities, combining their expertise for a more comprehensive perspective, and several have the backing of the SCDOT and local communities for research support. These proposals have been sent out to reviewers in academia and the industry for blind evaluations. Notification of funding will be given in late August, and the winning teams will start research then.

ONGOING RESEARCH

## Clemson University Connected Vehicles Testbed

The first South Carolina cyber-physical systems testbed for connected vehicles aims to enhance research for the C²M² partner institutions. This testbed is the continuation of the NSF USIGNITE funded project (US Ignite: Track 1: Enabling Connected Vehicle Applications through Advanced Network Technology (#1531127)). This Clemson University Connected Vehicles Testbed (CU-CVT), located in Clemson, South Carolina, includes heterogeneous wireless communication technologies and data infrastructure for real-time data exchanges, streaming, fusion and archiving. One key feature of the testbed is the layered architecture, which enables reducing data delivery delay for the services provided CU-CVT, and supports reducing bandwidth requirement and data loss rate to accommodate a large number of connected vehicles and run multiple diverse connected vehicle applications at the same time. C²M² researchers are utilizing the CU-CVT facilities for diverse multimodal transportation systems research. Future research projects will also use CU-CVT facilities for evaluating connected and autonomous vehicle safety, security and operations in a real-world setting.
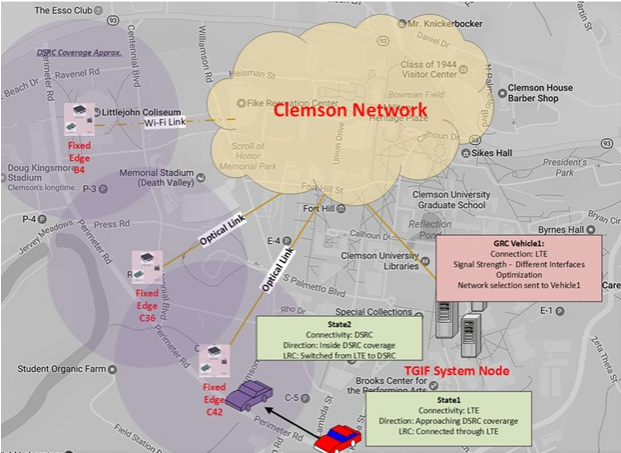
Toolkit Development for Connected Vehicle Research Data Sharing

One of the first research goals for C²M² was to develop a toolkit that will make our CU-CVT available to other institutions. The data generated from CU-CVT components are valuable for developing connected vehicle (CV) applications and conducting research. Many of the CV applications require the data to be shared online and in real time to be effective. Real time data sharing will support remote users (CV application developers and researchers) who do not have access to a


CV testbed, to develop and evaluate new applications as well as existing CV applications, thus supporting accelerated development of the CV environment. This project fills an existing gap in the CV domain by presenting a research data sharing platform for both real-time and archived CV data. Currently, C²M² students are working to develop a web-based program that can provide remote access to testbed components. The center will offer engineering support to help C²M² project teams to connect to and use the CU-CVT infrastructure. The center plans to have this toolkit available by the end of this summer.
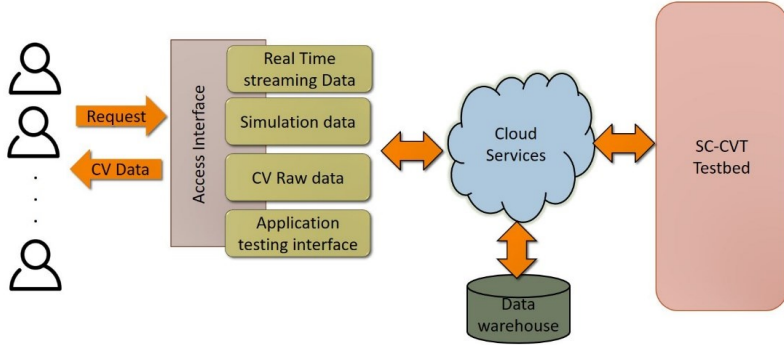
Security Platforms for Vehicle to Infrastructure (V2I) Network

Security is essential in a world of connected transportation. V2I requires the identification and analysis of interfaces for the purpose of developing security controls that afford the right level of protection given the data and means of data transmission. We are creating a new software-defined approach to secure V2I interfaces in the dynamic connected vehicles ecosystem. This will lead to the development of a security platform for the V2I network. We are working toward (a) developing and deploying novel network defenses tailored to various security requirements in a CV ecosystem, and (b) dynamically customizing a network's security posture for the current operating context of different vehicles and surrounding roadway environments.

We have developed CVGuard, which is a new software-based security architecture, designed to protect CVs in a V2I environment. The primary goal of CVGuard is to detect and isolate any cyberattacks in a V2I environment before they can negatively affect vehicles or transportation networks, potentially causing crashes and impeding the adoption of connected vehicle technologies. Our research based on a case study on Stop Sign Gap Assist, a V2I application, shows that in the presence of a Distributed Denial of Service (DDoS) attack, CVGuard was effective in reducing the rate of vehicle conflicts by 60%.
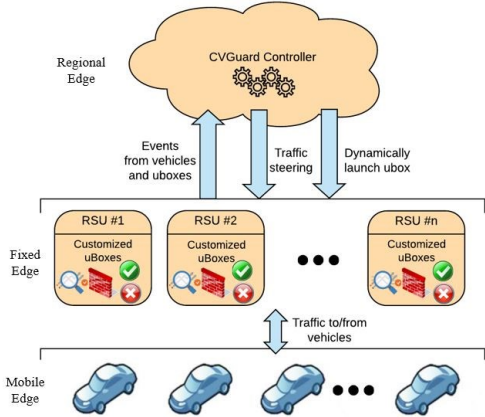
Special Thanks

We would like to say a special thank you to the Program Director, Vareva Harris, and all of the staff of Benedict College's Summer Transportation Institute (STI) for their help in making STI visits at Clemson University and USC a success! We appreciate all of the time and hard work that went into planning each of their visits and giving us an opportunity to share what we do with secondary school students. To learn more about this wonderful education program please check out their webpage at http://www.benedict.edu/cms/?q=node/1389.
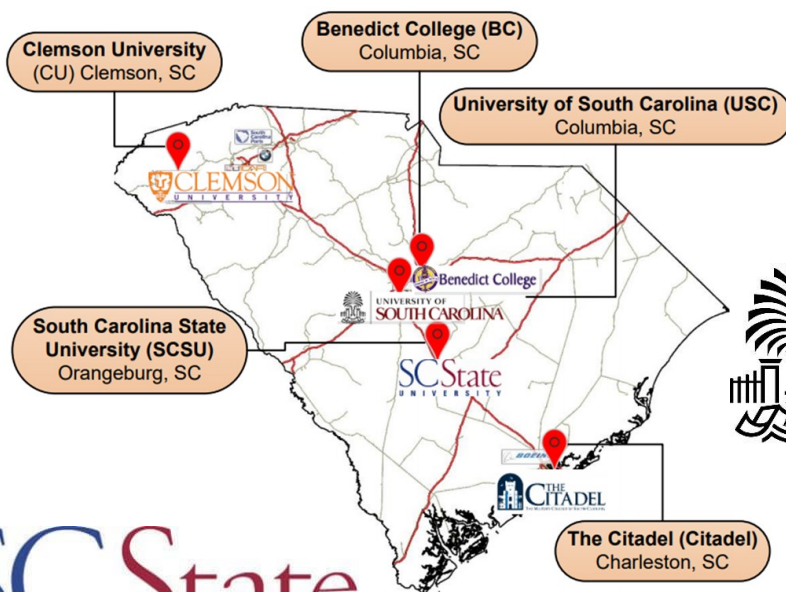
Vareva Harris, Program Director, Benedict College Summer Transportation Institute (STI)

See You Soon!

C^2M^2 News will be back next quarter to bring you more news on our progress. In the mean time, for comments, questions, or further information about the USDOT C^2M^2 and its activities feel free to email us at c2m2@clemson.edu or check out our website at cecas.clemson.edu/c2m2.