Driver-in-the-Loop Cyber-Transportation Systems

PIs: Chunming Qiao, Adel Sadek, Sean Wu and Kevin Hulme
State University of New York at Buffalo

University at Buffalo
*The State University of New York*

INTRODUCTION

The **C**yber-**T**ransportation **S**ystems (**CTS**) Project at State University of New York at Buffalo takes a multi-disciplinary approach that combines cyber technologies, transportation engineering and human factors.

The CTS project has two closely related objectives:
1) *Design and evaluate new CTS applications for improved traffic safety and traffic operations.*
2) *Design and develop an integrated traffic-driving-networking simulator.*

Our Research Vision

MOTIVATION

WARNING! DON'T READ DISTRACTING WARNING SIGNS WHILST DRIVING!
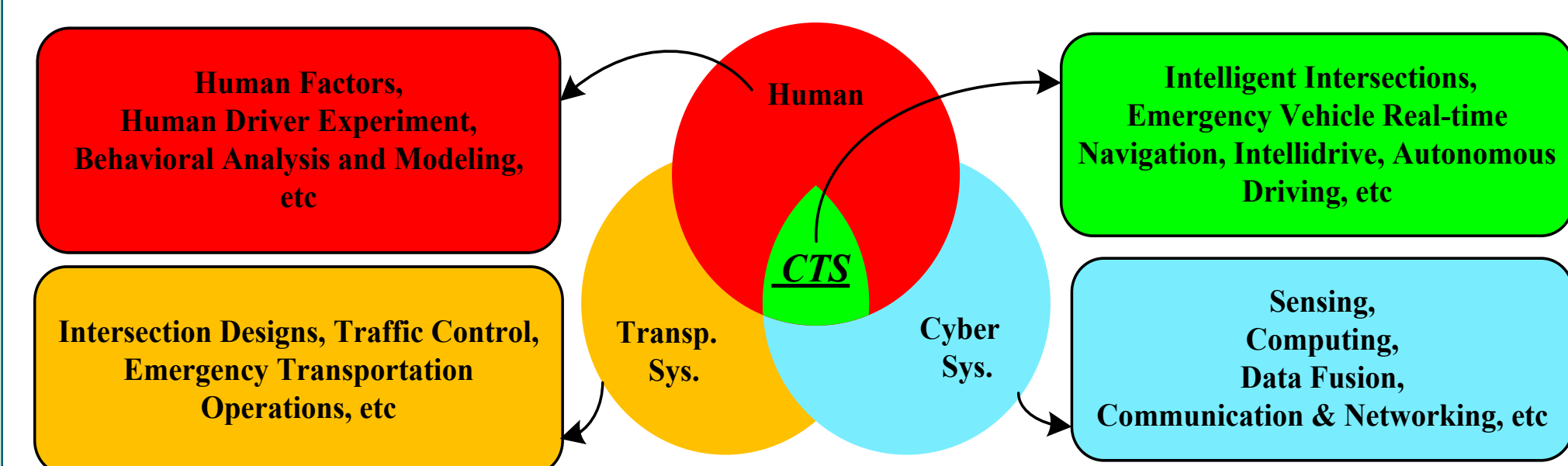
Credit: A. Exton, available at www.CartoonStock.com

U.S. transportation system has recently begun to show signs of serious strain. These signs include:
(1) massive gridlock and poor air quality in the nation's metropolitan areas;
(2) accidents that claim more than 40,000 lives;
(3) negative impacts on global climate change and energy availability.

Human driver behavior plays a key role in current transportation systems. The above figure shows a typical example illustrating why HF considerations should be taken into account when deploying various applications on intelligent vehicles.

To the best of our knowledge, research issues related to how to take HF into consideration when designing CTS applications and communications protocols have not been adequately addressed.

PROJECT OBJECTIVES

Human-Factors aware CTS Research
>*Improve driver/passenger safety, and emergency operation*
>*Improve transportation efficiency*
>*Reduce congestion, fuel consumption and CO_2 emission*
>*Provide infotainments*
>*Increase productivity*

Technology transfer and Training/Education
>*Automobile industry and governmental agencies*
>*Senior and youth drivers training and rehabilitation*
>*Graduate and undergraduate student education*

OUR RESEARCH FOCUS

Human Factors (HF) in CTS
>*Driver perception of and reaction to traffic alerts/warnings*
>*Driving behavior analysis*
>*Driver performance modeling*
>*Workload estimation*
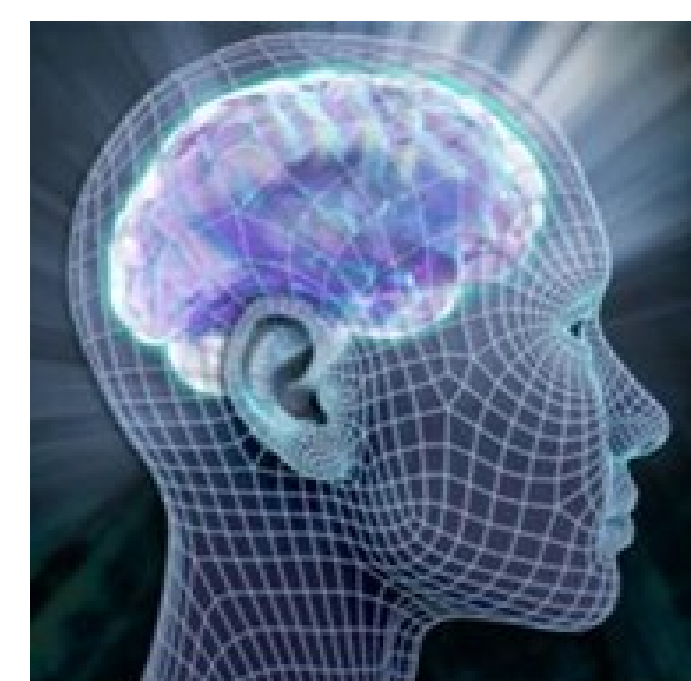
HF-aware CTS Systems and Protocols
>*MAC and routing protocols for CTS messages*
>*High-level data fusion*
>*Integrated network architecture*
>*Intelligent intersection design*
>*Emergency vehicle routing*
>*Operations in extreme events*
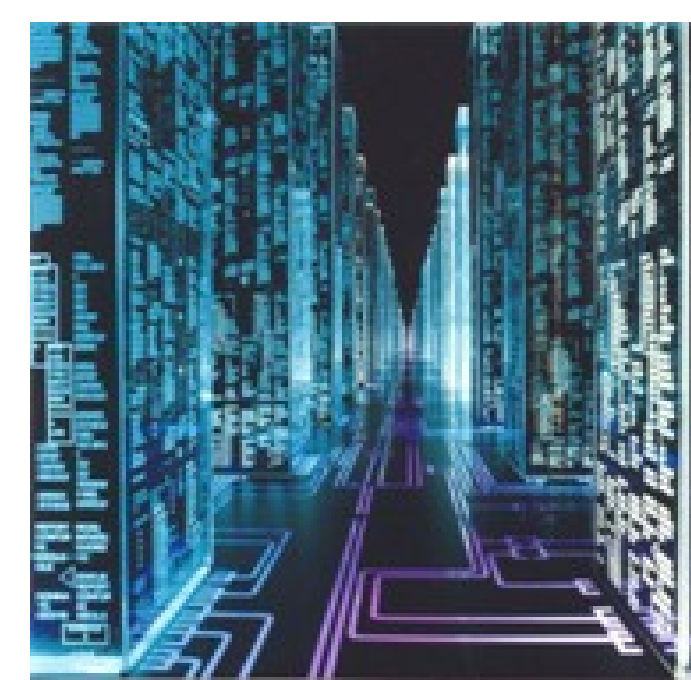
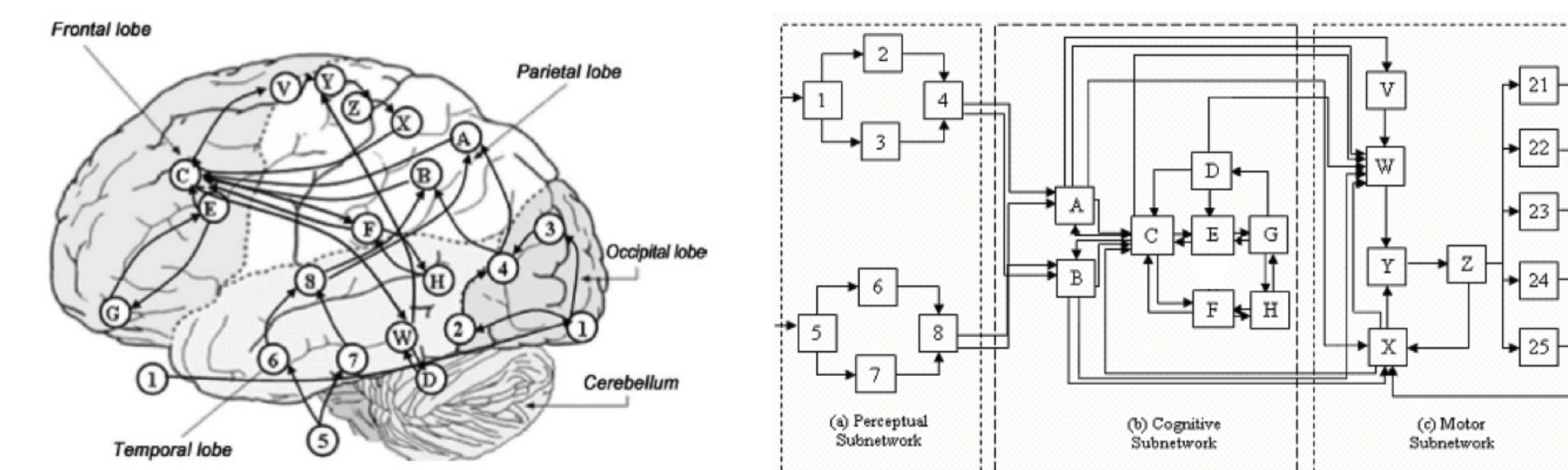### 3-in-1 Simulator as a Tool for CTS R&D Integrating
>*Traffic Simulator (e.g. PARAMICS, SUMO)*
>*Driving Simulator (e.g., STISIM, CARSIM)*
>*Network Simulator (e.g., NS2, NS3)*

The research topics in this project are highly related and will be studied jointly.
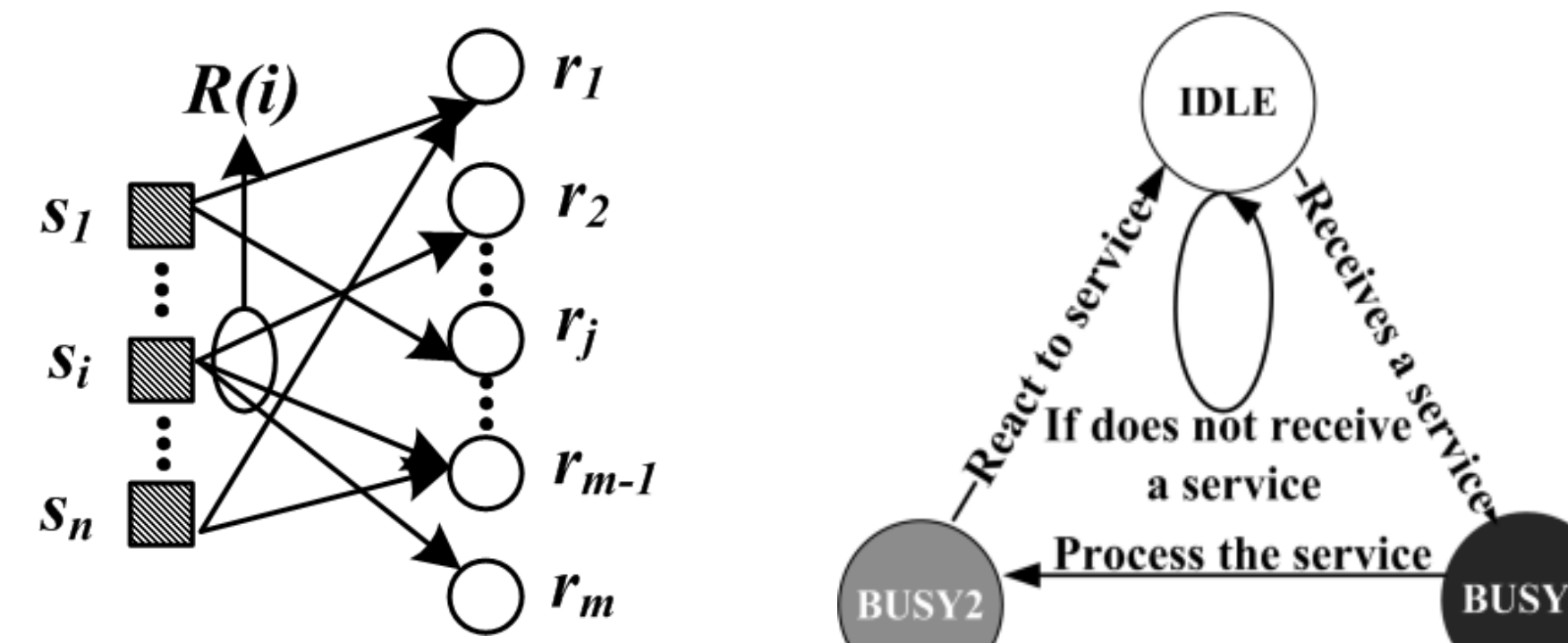

SELECTED RESEARCH TOPICS

Queuing Network - Model Human Processor (QN-MHP)

(General Structure of QN-MHP)   (Mapping Servers onto Brain Areas)
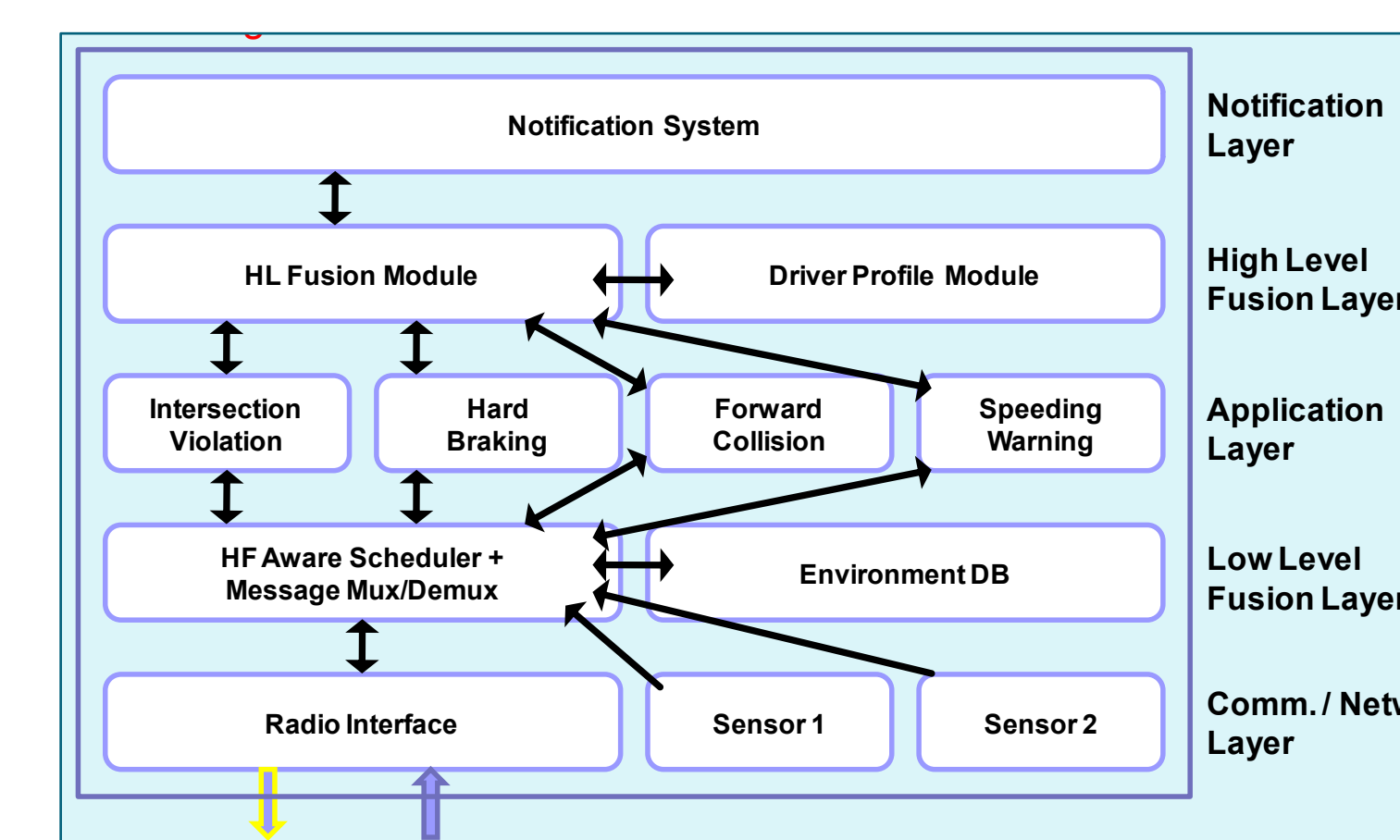
Human Factor-aware Service Scheduling

(Services and receivers)   (Services delivery process)

Problem: How to schedule messages to maximize gains?

Service Scheduling	r_1	r_2	r_3	r_4	r_5	r_6	$UL_i(*)$
$t=1$, s_1 (r_1, r_3, r_5), $C_1=20$	○	○	○	○	○	○	0
$t=2$, s_2 (r_1, r_2, r_6), $C_2=40$	●	○	○	○	○	○	1×40=40
$t=3$, s_3 (r_3, r_4), $C_3=60$	●	○	●	○	●	○	1×60=60
$t=4$, s_4 (r_1, r_2, r_4, r_6), $C_4=80$	●	●	○	●	○	●	3×80=240
$t=5$, s_5 (r_1, r_2, r_6), $C_5=100$	●	○	○	●	○	○	1×100=100

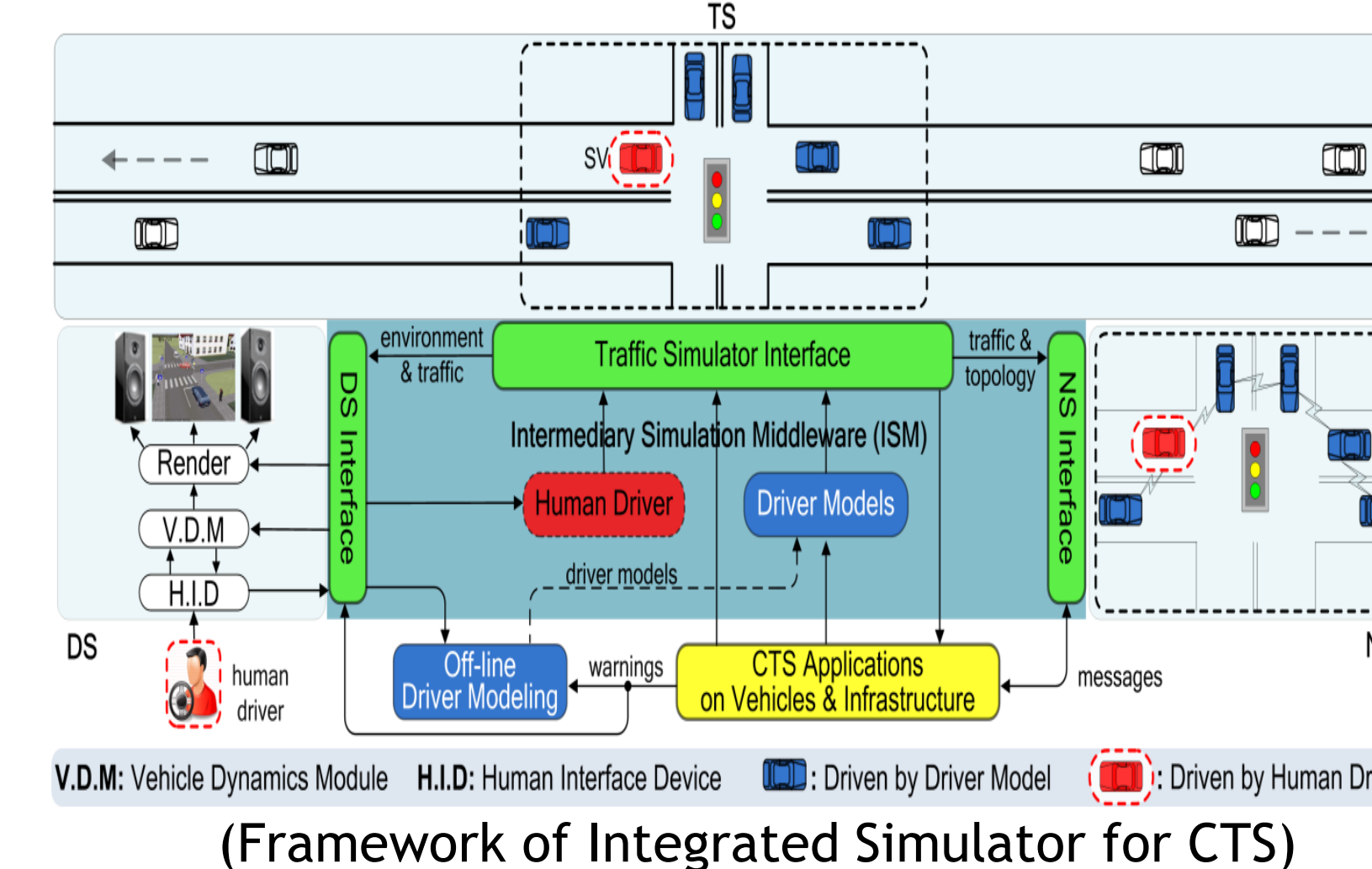(An example)

High-Level Data Fusion
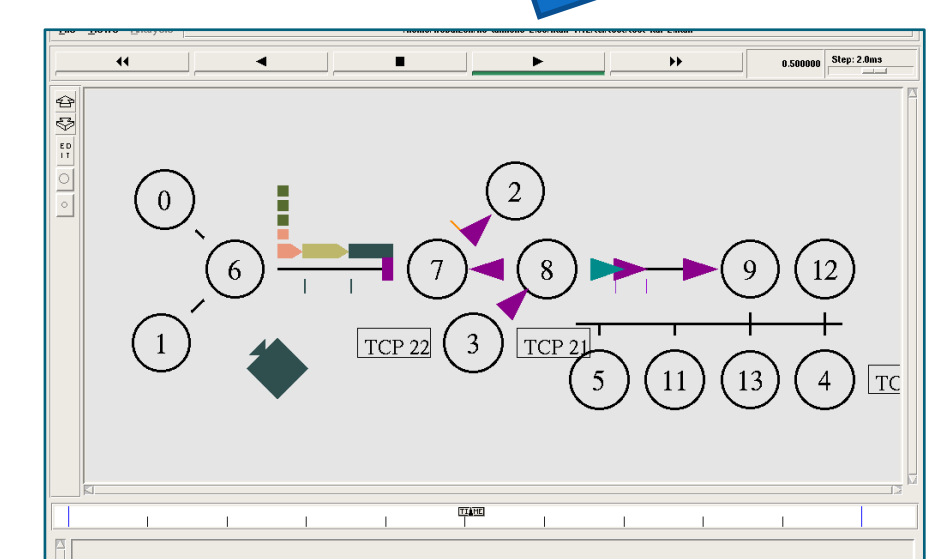

(Multi-Layered Architecture for Data-Fusion)

Integrated Simulator Architecture

(Framework of Integrated Simulator for CTS)

Facilities at UB

Network Simulator

Driving Simulator

Traffic Simulator (Paramics)

RECENT PUBLICATIONS

[1] Aditya Wagh, Xu Li, J. Wan, C. Qiao and C. Wu, "Human Centric Data Fusion in Vehicular Cyber-Physical Systems," *The First International Workshop on Cyber-Physical Networking Systems(CPNS)*, in conjunction with INFOCOM, Shanghai, China, 2011.

[2] Xu Li, Xuegang Yu, Aditya Wagh, and Chunming Qiao, "Human Factors-aware Service Scheduling in Vehicular Cyber-Physical Systems," *The 30th IEEE International Conference on Computer Communications (IEEE INFOCOM 2011)*, Shanghai, China, April, 2011.

[3] A.W. Sadek, Y. Zhao, S. Huang, D. Fuglewicz, K. Hulme, and C. Qiao, "Advanced Transportation Simulation Modeling for Transportation System Evaluation and Management during Emergencies," Accepted for publication in Journal of Homeland Security.

[4] K. F. Hulme, S. Huang, A. W. Sadek, and C. Qiao, "Next Generation, Integrated Hardware-in-the-loop Transportation Simulation Modeling," *The Interservice/Industry Training, Simulation and Education Conference (I/ITSEC 2010)*, Orlando, FL, November, 2010.

[5] G. Zhao, C. Wu, "Mathematical Modeling of Average Driver Speed Control with the Integration of Queuing Network-Model Human Processor and Rule-Based Decision Field Theory," *55th Annual Meeting of Human Factors and Ergonomics Society (HFES)*. Las Vegas, Nevada, September 19-23, 2011.

For more information, please refer to CTS project website:

http://www.cse.buffalo.edu/CTS/index.htm