MDOT-MSU Traffic State Monitoring System

4th Project Progress Meeting

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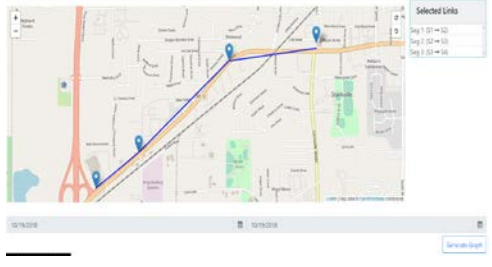
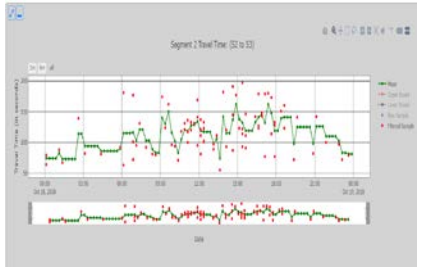
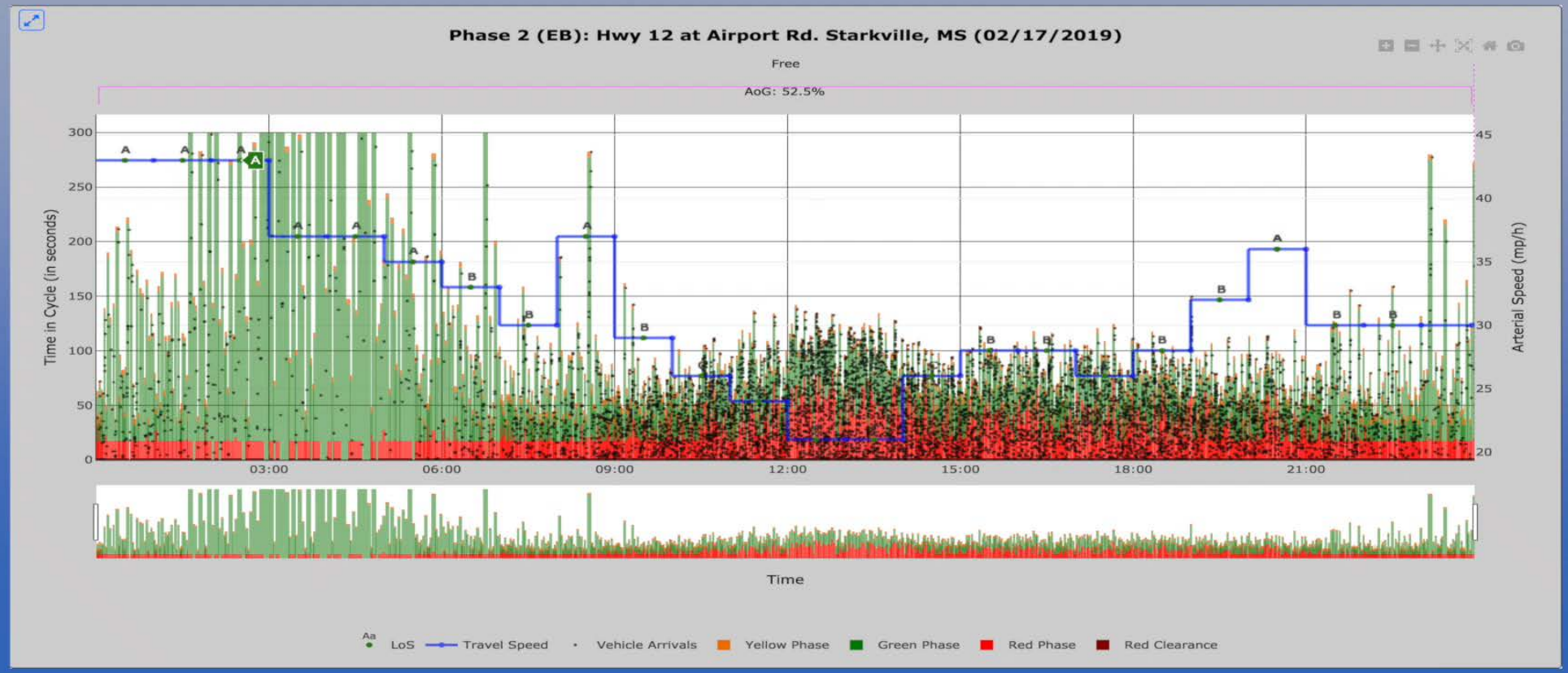





Outline

- Recap
- New Development and new features
- Demonstration
- New findings
- Next step



https://youtu.be/GiMGftcSyjs

Recap:project timeline

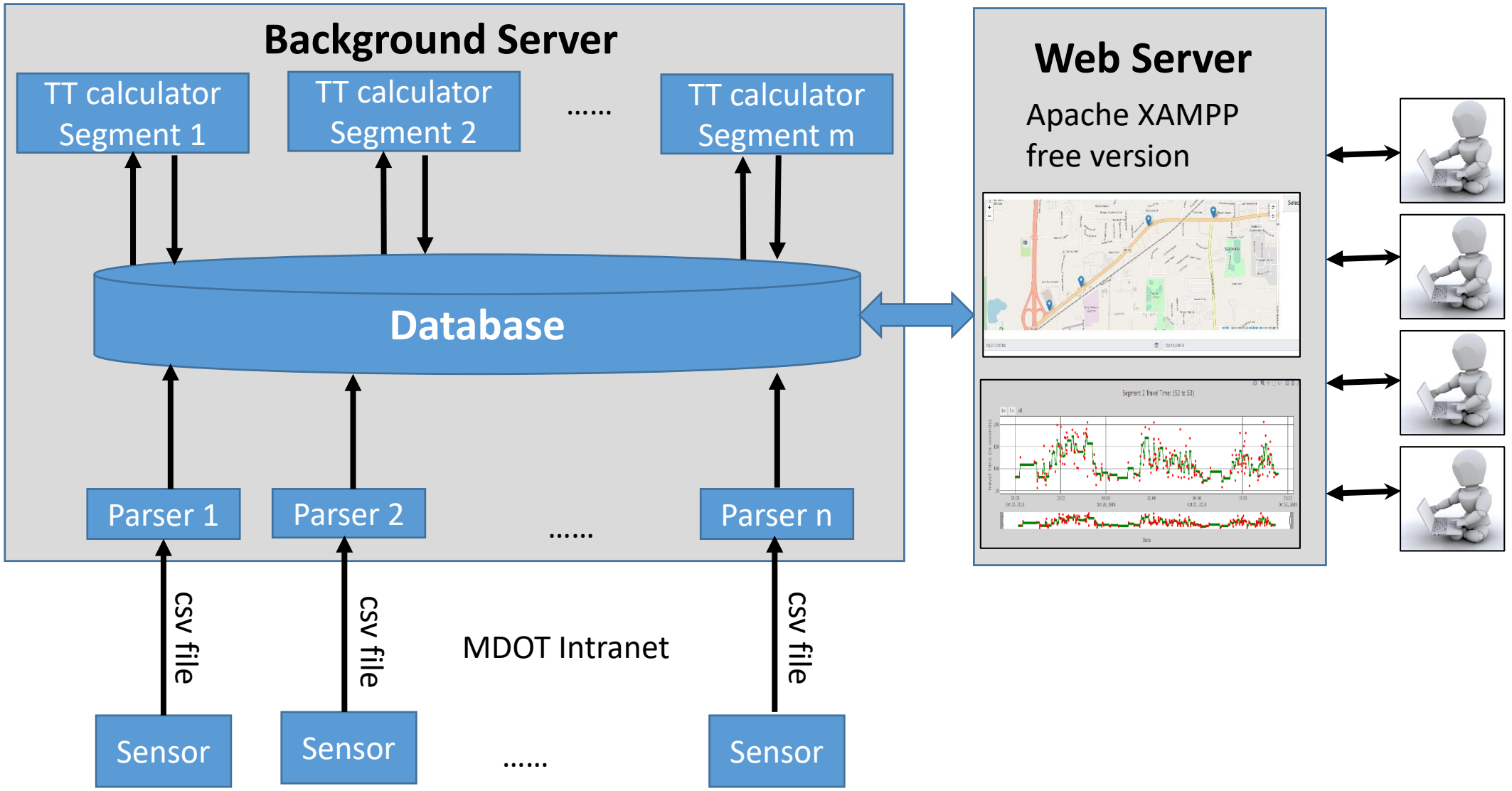
		Progress	Start																						
		Year	1											2											
		Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Task No.	Description	Efforts percentag																							
1	Inventory survey	5%																							
2	Wi-Fi sensors	5%																							
3	Central System for travel time	25%																							
4	Wi-Fi Field evaluation and report	10%																							
5	Wi-Fi sensor upgrade	5%																							
6	Synchronnize PCD with Wi-Fi TT	35%																							
7	Final Report	15%																							

Finished

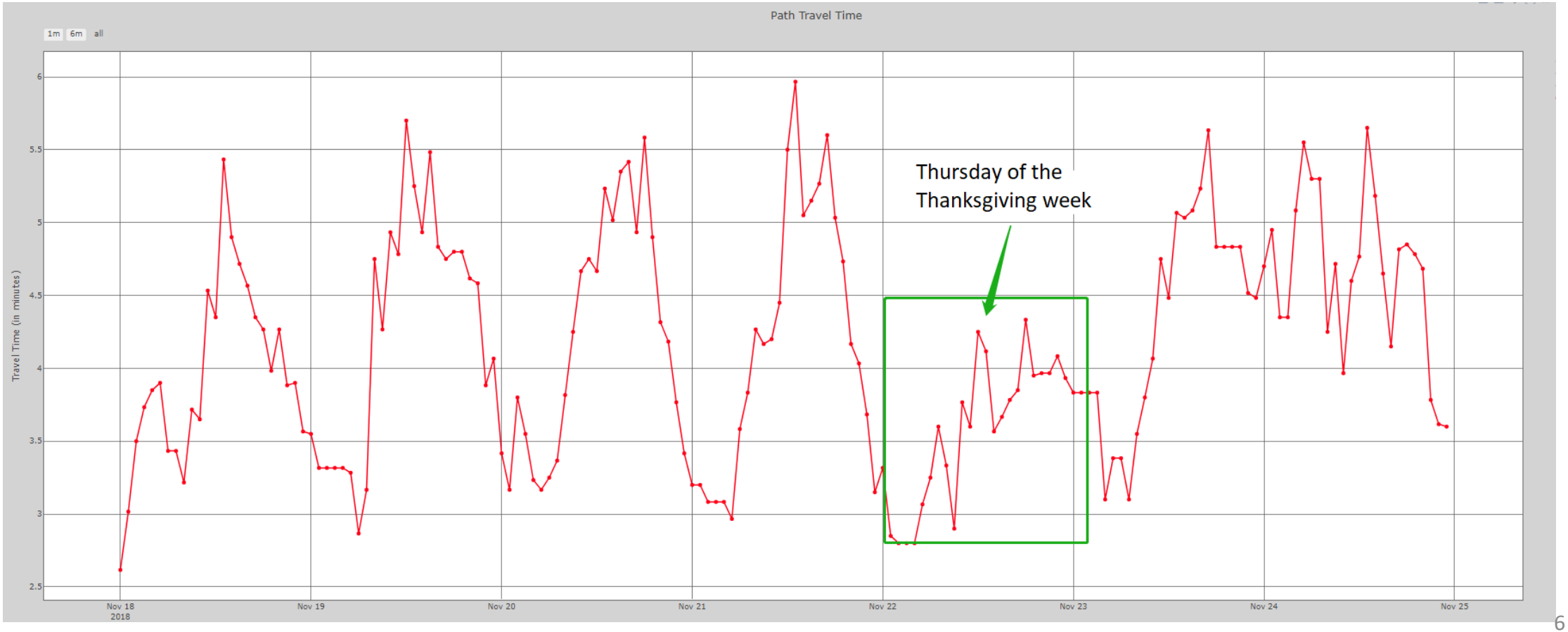
Prototype/System deliverables

Report/Memorandum deliverables

Recap 2: Scalable System architecture



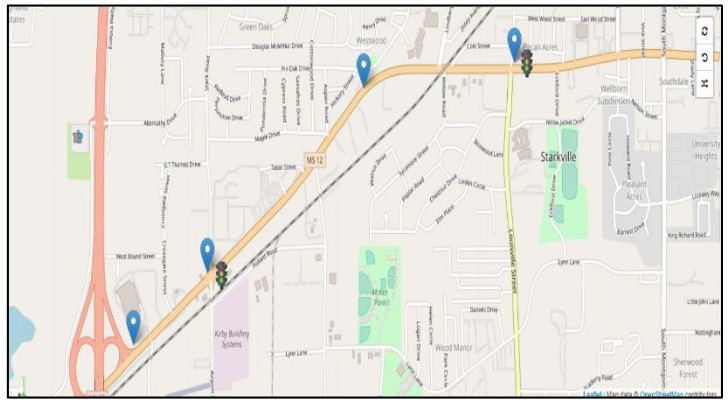
Reap 3: Travel time patterns

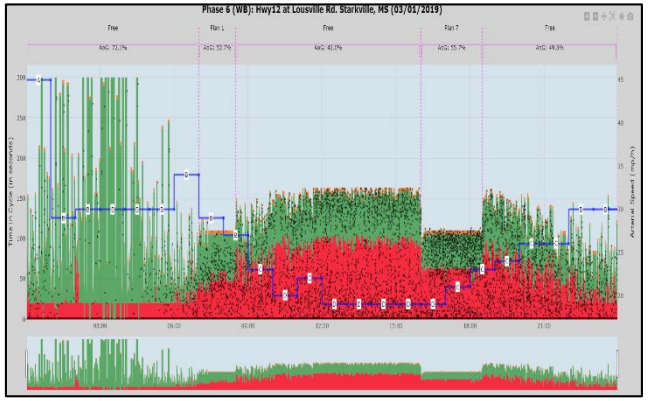


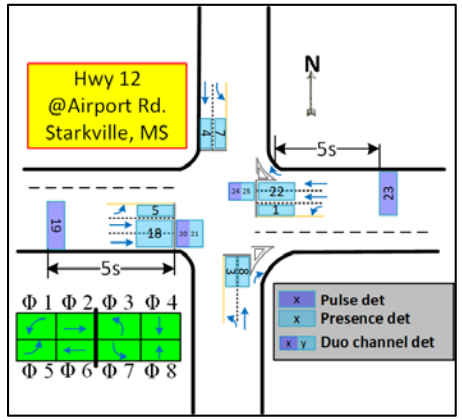
New Development

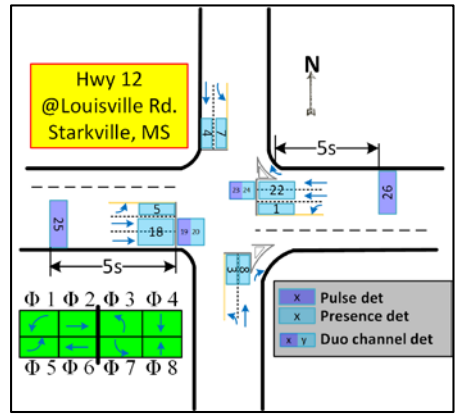
- Nov-Dec, 2018:
  - Wi-Fi sensor modification to retrieve traffic signal event data from Siemens M60 controller (Linux)
  - Wi-Fi sensor is multi-functional now.

- Jan-Feb, 2019:
  - Set up detectors (In Wavetronix) for traffic signal performance system on Highway 12 at Airport Road and Louisville Rd.
  - Developed traffic signal performance diagram (Purdue Coordination Diagram)

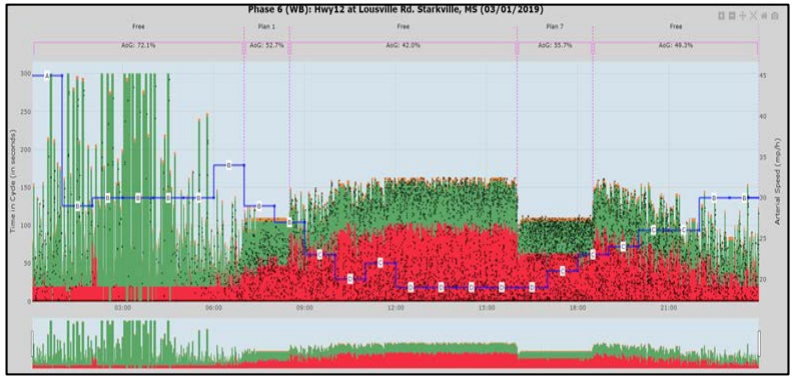




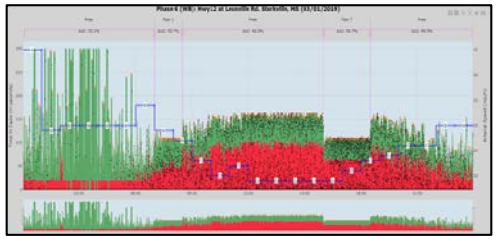




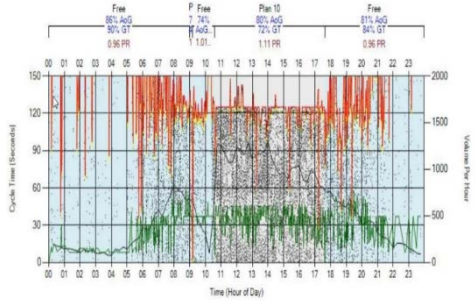
New Features



- Display synchronous arrivals on green (new) and arterial travel time (traditional) MOEs in the same diagram
  - Both are important to understand the arterial traffic signal performance
  - The 1st system of its kind nation wide
- Display time-of-day timing plan according to traffic signal event (130)
- Histogram-style display, more straightforward
  - Other similar systems use trend curves



MDOT-MSU System



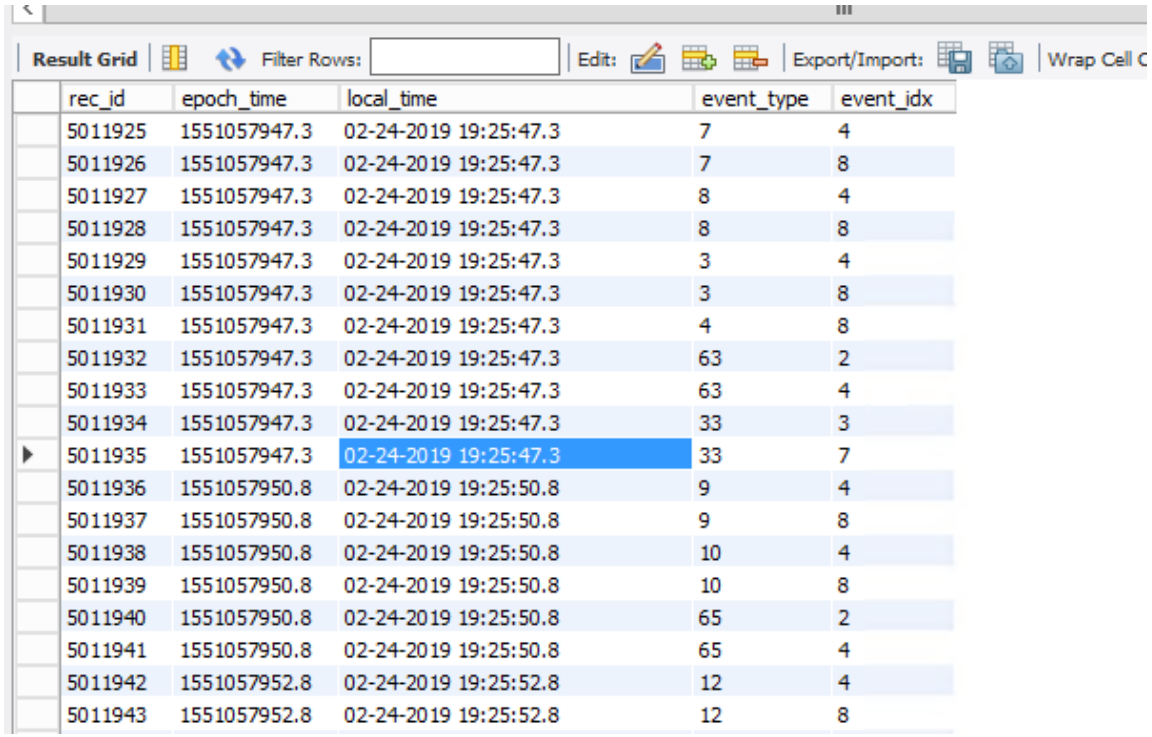
UDOT System

- Interactive diagram, allows users to zoom in to see more details and zoom out to see the big picture

What is traffic signal event data?

- System detectors (connected to traffic signal cabinet) have been used to collect traffic states on arterials
  - Traditionally, The reported data, such as counts, occupancies or green usages, are aggregated from individual traffic signal events every 5, 10, 15 min or hour
- Dr. D. Bullock and his research group at Purdue University first proposed the concept of “high-resolution” (i.e., individual) traffic signal events and design new traffic state methods with the type of data
  - They also developed the “de facto” standards for traffic signal event definitions
  - Most Linux controllers today generate such data, such as Siemens M60

References: https://docs.lib.purdue.edu/jtrpaffdocs/3/



Result Grid | Filter Rows: | Edit: | Export/Import: | Wrap Cell C

rec_id	epoch_time	local_time	event_type	event_idx
5011925	1551057947.3	02-24-2019 19:25:47.3	7	4
5011926	1551057947.3	02-24-2019 19:25:47.3	7	8
5011927	1551057947.3	02-24-2019 19:25:47.3	8	4
5011928	1551057947.3	02-24-2019 19:25:47.3	8	8
5011929	1551057947.3	02-24-2019 19:25:47.3	3	4
5011930	1551057947.3	02-24-2019 19:25:47.3	3	8
5011931	1551057947.3	02-24-2019 19:25:47.3	4	8
5011932	1551057947.3	02-24-2019 19:25:47.3	63	2
5011933	1551057947.3	02-24-2019 19:25:47.3	63	4
5011934	1551057947.3	02-24-2019 19:25:47.3	33	3
5011935	1551057947.3	02-24-2019 19:25:47.3	33	7
5011936	1551057950.8	02-24-2019 19:25:50.8	9	4
5011937	1551057950.8	02-24-2019 19:25:50.8	9	8
5011938	1551057950.8	02-24-2019 19:25:50.8	10	4
5011939	1551057950.8	02-24-2019 19:25:50.8	10	8
5011940	1551057950.8	02-24-2019 19:25:50.8	65	2
5011941	1551057950.8	02-24-2019 19:25:50.8	65	4
5011942	1551057952.8	02-24-2019 19:25:52.8	12	4
5011943	1551057952.8	02-24-2019 19:25:52.8	12	8

Active Phase Events
- 0 Phase On
- 1 Phase Begin Green
- 2 Phase Check
- 3 Phase Min Complete
- 4 Phase Gap Out
- 5 Phase Max Out
- 6 Phase Force Off
- 7 Phase Green Term
- 8 Phase Begin Yellow Cl
- 9 Phase End Yellow Cl
- 10 Phase Begin Red Cl
- 11 Phase End Red Cl
- 12 Phase Inactive

Active Pedestrian Events
- 21 Ped Begin Walk
- 22 Ped Begin Clearance
- 23 Ped Begin Don't Walk
- 24 Ped Dark

Ped Dark Barrier/Ring Events
- 31 Barrier Term [1]
- 32 FYA Begin Perm [2]
- 33 FYA End Perm [2]

Phase Control Events
- 41 Phase Hold Active
- 42 Phase Hold Released
- 43 Phase Call Registered
- 44 Phase Call Dropped
- 45 Ped Call Registered
- 46 Phase Omit On
- 47 Phase Omit Off
- 48 Ped Omit On
- 49 Ped Omit Off

Notes:
[1] Barrier is identified by the number of the phase preceding it in the ring
[2] FYA is identified by the number of the corresponding protected phase.
[3] Event is not yet supported.
* Underlying feature not supported.

Overlap Events
- 61 Overlap Begin Green
- 62 Overlap Begin Trailing Green
- 63 Overlap Begin Yellow Cl
- 64 Overlap Begin Red Cl
- 65 Overlap Off
- 66 Overlap Dark
- 67 Ped Overlap Begin Walk *
- 68 Ped Overlap Begin Clearance *
- 69 Ped Overlap Begin Don't Walk *
- 70 Ped Overlap Dark *

Detector Events
- 81 Detector Off
- 82 Detector On
- 83 Detector Restored
- 84 Detector Fault – Other
- 85 Detector Fault – Watchdog
- 86 Detector Fault – Open Loop
- 87 Detector Fault – Shorted Loop
- 88 Detector Fault – Excess Change
- 89 Ped Detector Off
- 90 Ped Detector On
- 91 Ped Detector Failed
- 92 Ped Detector Restored

Preemption Events
- 101 Preempt Adv Warning *
- 102 Preempt Input On
- 103 Preempt Gate Down *
- 104 Preempt Input Off
- 105 Preempt Entry Started
- 106 Preempt Begin Track Cl
- 107 Preempt Begin Dwell
- 108 Preempt Link Active On
- 109 Preempt Link Active Off
- 110 Preempt Max Pres. Exceeded
- 111 Preempt Begin Exit
- 112 TSP Check In
- 113 TSP Adjust Early
- 114 TSP Adjust Late
- 115 TSP Check Out

What is Arrivals on Green diagram? (a.k.a. Purdue Coordination Diagram)

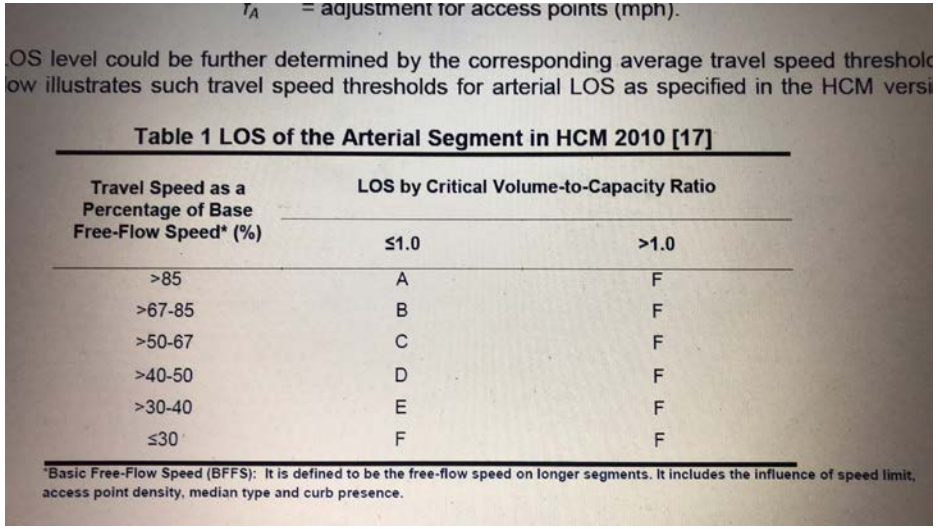
Development Objective

- Address the surfacing argument like below:
  - **Should we still use the arterial travel time as the arterial signal performance MOE or replace it with the new MOE, arrivals on greens?**

- The new system aims at including both MOEs to provide a more comprehensive traffic signal performance evaluations.

Definitions of two traffic signal performance MOE

- Arterial level of service (LOS) defined by HCM 2010:
- Measured Speed as opposed to free flow speed



r_A = adjustment for access points (mph).

OS level could be further determined by the corresponding average travel speed threshol
ow illustrates such travel speed thresholds for arterial LOS as specified in the HCM versi

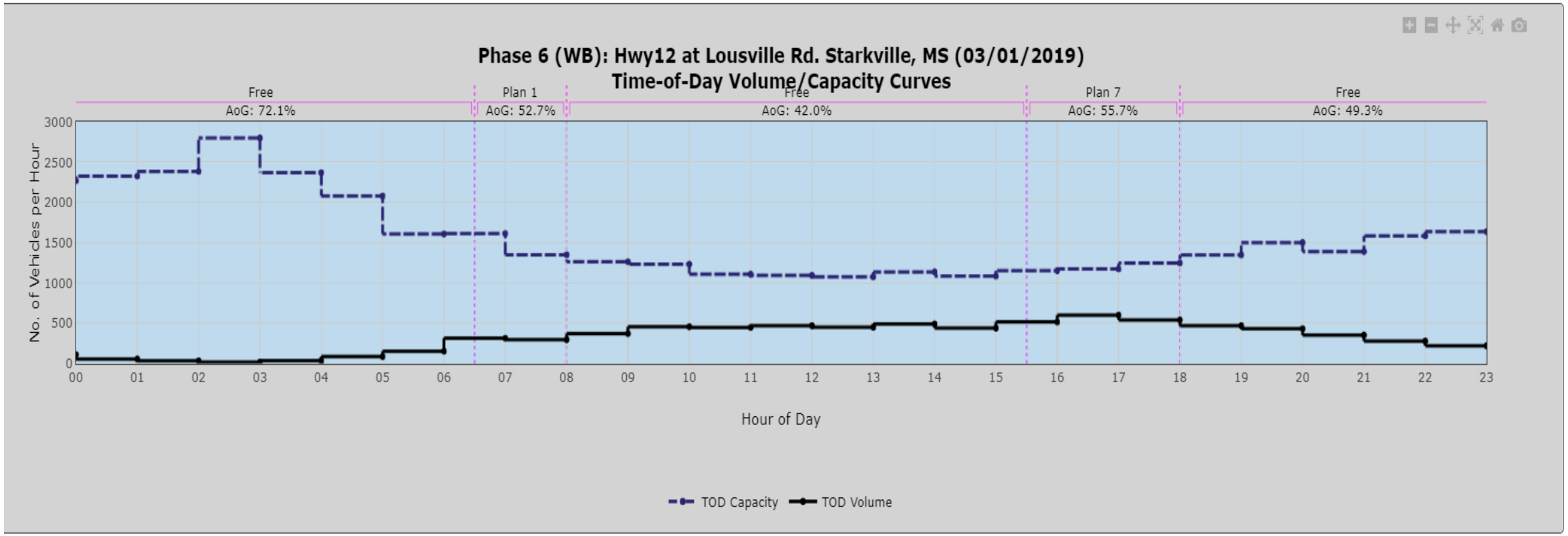
Table 1 LOS of the Arterial Segment in HCM 2010 [17]

Travel Speed as a Percentage of Base Free-Flow Speed* (%)	LOS by Critical Volume-to-Capacity Ratio	
	≤1.0	>1.0
>85	A	F
>67-85	B	F
>50-67	C	F
>40-50	D	F
>30-40	E	F
≤30	F	F

*Basic Free-Flow Speed (BFFS): It is defined to be the free-flow speed on longer segments. It includes the influence of speed limit, access point density, median type and curb presence.

- % Arrivals on Green
  - The percentage of vehicles arriving at the stop line during the green and cross without stopping

TOD volume vs. capacity



Sensor new features

- Backup signal event data in the sensor for up to one month
  - In case of network disconnection, we could manually upload traffic signal event data.
- Self-diagnose and clock calibration at 1 AM everyday
  - To improve the sensors' reliability
  - The sensors have been live since they were installed.
- Send 2 copies of raw data to MDOT virtual machine and MSU virtual machine

Demonstration

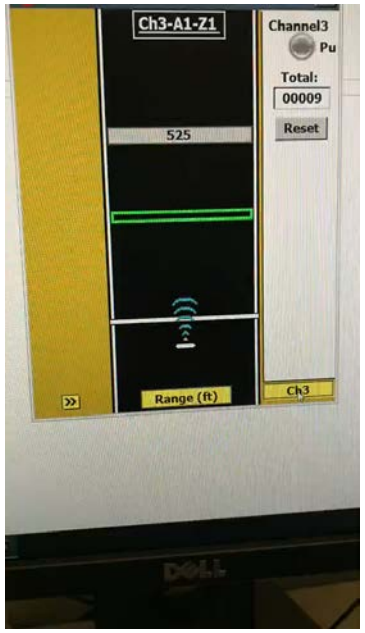
New findings (1)

- M60 controllers miss logging event data from time to time
  - Some programming tricks must be implemented to fill the missing data in visualization

- Network connection is not 100% reliable
  - In this project, data transmission route is very long: Starkville->Jackson->Starkville->Jackson (or further back to Starkville)
  - Data transmission is implemented every hour
  - We decide to keep a copy of raw traffic signal event data for up to a month in case some needed data are missing while transmitting

New findings (2)

- Wavetronix detectors in Starkville
  - Advance detection are not for counting arrivals
  - We plan to conduct more experiments to evaluate the counting accuracy with Wavetronix advance detectors
  - New vehicle counting techniques are necessary to capture all arrivals.



Recorded time: 10:30 AM Marh-4-2019

New findings (3)

- Database size may significantly affect the system performance
  - Up to 24 hours of PCD diagram is allowed to be generated
  - Traffic Signal Event data are only keep for 7 days (a week) and then permanently deleted.
    - **It can be kept for a longer time if necessary**
  - Raw Wi-Fi MAC addresses are only kept for one day to match travel time samples and then permanently deleted.
    - **Wi-Fi travel time samples have no limit for archiving**.

Next Steps

- System Fine tuning and bug removing until the end of this project (Jan-2020)
  - Can be supported by this project
- Brief documentation of system deployments and user manual
  - Can be supported by this project

- Deploy at the new locations where it may be more needed
  - Some new experiments will be necessary
  - **Need new support**
- Conduct a full-spectrum study using this system to develop insights for MDOT traffic operations
  - Existing performance evaluation->Possible cures->new performance evaluation
  - Optimization automation
  - **Need new support**
- Provide extensive documentation and training about this system for MDOT and/or other agencies
  - **Need new support**