INTEGRATING CLARUS DATA IN TRAFFIC SIGNAL SYSTEM OPERATION:

A SURVIVABLE REAL-TIME WEATHER RESPONSIVE SYSTEM

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Project Team

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- Students Involved
  - Mohamed Islam [M. Sc., Civil Engineering]
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Project Overview

- Develop a prototype of a real-time weather-responsive traffic signal control system to improve the efficiency and safety of traffic signal operations during inclement weather
- The proposed system will receive weather information from the FHWA's Clarus system database, analyze it, and make necessary changes to signal timing parameters in response to inclement weather conditions.

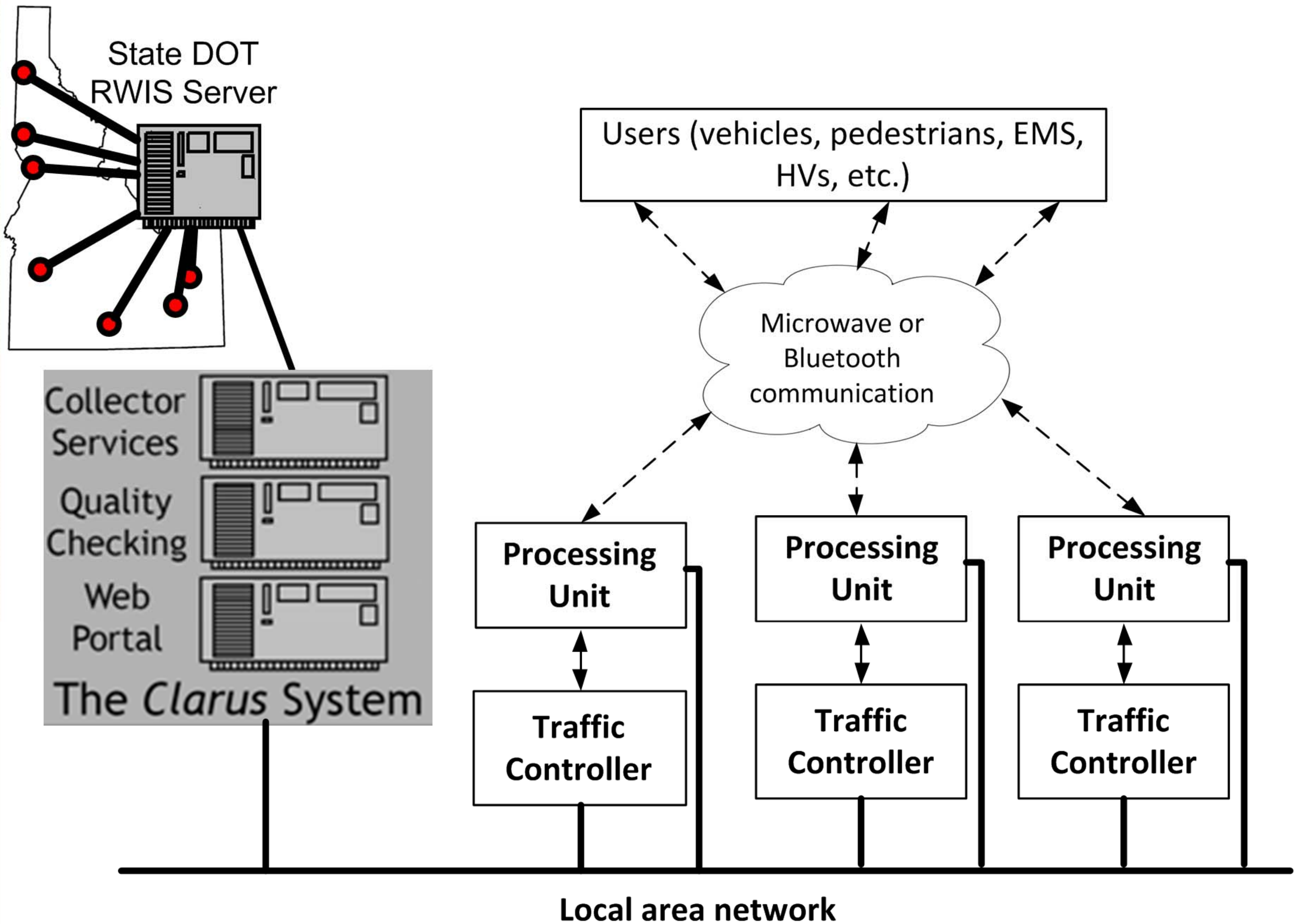
Project Overview

- The proposed system will operate and achieve its potential using current traffic controller and controller cabinet technologies. Minimal hardware, in addition to traffic controllers, will be required for full implementation.
- The system will be compatible with future applications within the FHWA's IntelliDrive initiative.

Project Overview

- Computer driven algorithms will implement traffic signal control decisions using Clarus data.
- Software design will incorporate self diagnostic techniques for fault detection and recovery to maximize security and minimize cost.

Proposed Project Architecture



Processing Unit

- The Rabbit 3000 microprocessor is proposed for the processing unit used in this project and meets the functional requirements for real-time traffic control feedback. This type of microprocessor is designed specifically for embedded control, communications, and Ethernet connectivity.

Processing Unit/Traffic Controller Communication

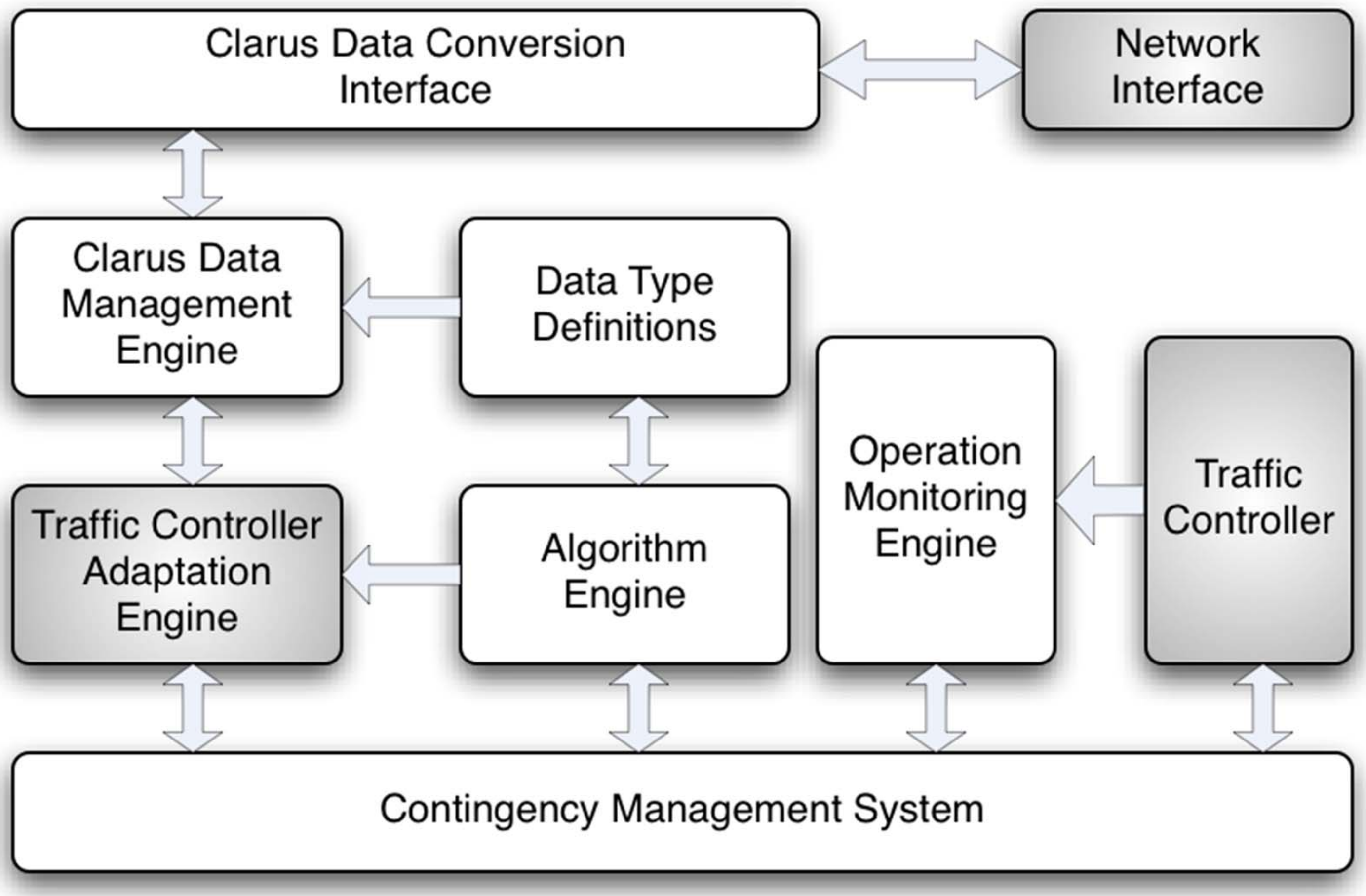
- The Dynamic Object STMP/UDP/IP Ethernet protocol stack is used to facilitate the NTCIP-based communication between the microprocessor and the traffic controller

Object Name	Access Rights	Object Name	Access Rights
phaseStatusGroupGreens	Read-only	phaseMaximum	Read-write
phaseStatusGroupYellows	Read-only	phaseStatusGroupPhaseNexts	Read-only
phaseStatusGroupReds	Read-only	phaseControlGroupPhaseOmit	Read-write
phaseMinimumGreen	Read-write	SensorInput	Read-only
phasePassage	Read-write		

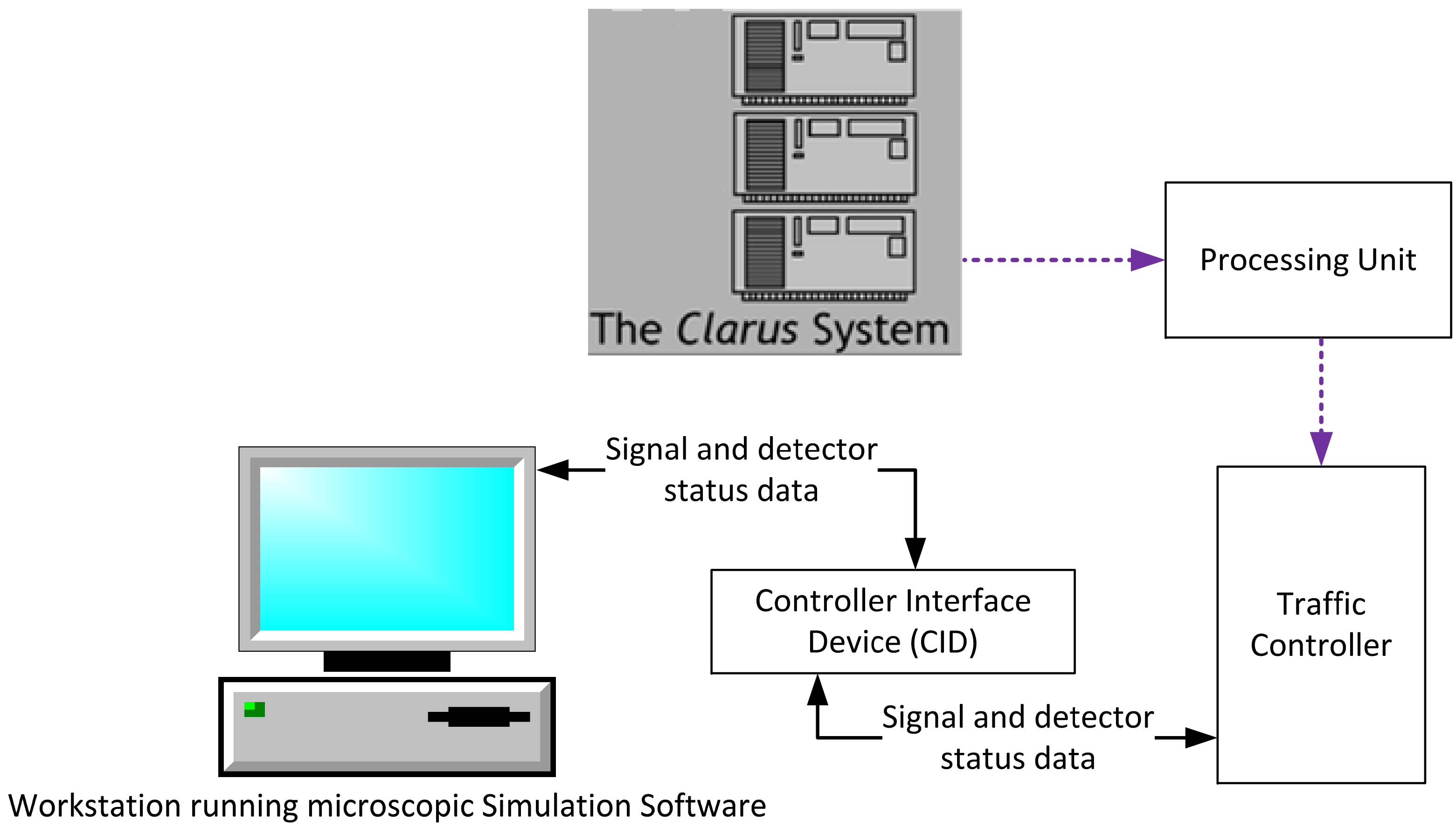
Software Architecture

- Two new approaches:
  - Design for Survivability
  - A Measurement-Based Methodology (MBM) for Embedded Systems
- Software Architecture Components
  - *Network Interface*
  - *Clarus Data Conversion Interface*
  - *Algorithm Engine*
  - *Clarus Data Management Engine*
  - *Traffic Controller Adaptation Engine*

Software Architecture



Developing the Testing Environment



A Survivable Architecture for Real-Time Weather Responsive Systems

- **Subscription to Clarus Weather Data**: We made a subscription to Clarus Data. This is a combination of data from three difference stations that are in close proximity to Moscow, Idaho. The URL is : http://www.clarus-system.com/SubFolder.jsp?subId=2011011000

- **Getting Data from Clarus**: We investigated the best way of getting the subscribed weather data from the Clarus system to the Rabbit microprocesser device which will be used to communicate with the traffic controllers. We were able to deduce through the use of the http protocols implementation in dynamic C (language of Rabbit) the process of getting this data transfer done from the Clarus to our proposed software running on Rabbit.

A Survivable Architecture for Real-Time Weather Responsive Systems

- **Dealing with Real-Time Response Issues of the Proposed System**: We investigated several possibilities of handling real-time issue as it concerns the getting of data from the Clarus, stripping off unwanted data, analyzing the data, taking decision on the type of control message to be sent to the traffic controller and at the same time monitoring of the running program for instances of attacks, malfunctioning, errors, etc. We explored various approaches that are used in Dynamic C to realize multi-tasking, both pre-emptive and cooperative multi-tasking. At this time, we agreed that the ***Costatement*** function (a cooperative multi-tasking method) available in Dynamic C is most suitable to handle these real-time issues.

A Survivable Architecture for Real-Time Weather Responsive Systems

- **Identifying the Level of Required Software Instrumentation:** We are the stage of determining and identifying the level of instrumentation that are necessary for the proposed software system. This will constitute the software telemetry. Since Dynamic C has no existing function to handle profiling, we are investigating the effective means of realizing this instrumentation (e.g. writing our own embedded routines) without necessarily impeding the performance of the proposed software system.

A Survivable Architecture for Real-Time Weather Responsive Systems

- **Timing Factor Investigation:** We are also at the moment concern about issues of deadlines, synchronization of systems (Clarus, Traffic Controller, Rabbit) time and process timeliness. The questions are: Are there deadlines that must be met? How do we ensure that the Clarus time is in agreement with Rabbit time?

Highly Critical (Essential) Clarus Data

essPrecipSituation	Describes the weather situation in terms of precipitation, integer values indicate situation
essPrecipYesNo	Indicates whether or not moisture is detected by the sensor: (1) precip; (2) noPrecip; (3) error
essPrecipRate	The rainfall, or water equivalent of snow, rate
essRoadwaySnowpackDepth	The current depth of packed snow on the roadway surface
essAirTemperature	The dry-bulb temperature; instantaneous
essVisibilitySituation	integer value, describes the travel environment in terms of visibility
essVisibility	Surface visibility (distance)
essSurfaceStatus	integer value, a value indicating the pavement surface status

Highly Critical (Essential) Clarus Data

essSurfaceTemperature	The current pavement surface temperature
windSensorGustSpeed	The maximum wind gust recorded by the wind sensor during the 10 minutes preceding the observation
essSnowfallAccumRate	The snowfall accumulation rate
essIceThickness	Indicates the thickness of the ice on surface
essPrecipitationStartTime	The time at which the most recent precipitation event began
essPrecipitationEndTime	The time at which the most recently completed precipitation event ended
essMobileFriction	Indicates measured coefficient of friction

Potentially Useful Data

windSensorAvgSpeed	A two-minute average of the windspeed
essPrecipitationOneHour	The total water equivalent precipitation over the one hour preceding the observation
essSurfaceIceOrWaterDepth	The current thickness of ice or depth of water on the surface of the roadway
essSurfaceBlackIceSignal	integer, A value indicating if Black Ice is detected by the sensor
essPavementTemperature	The current pavement temperature 2-10 cm below the pavement temperature.
pavementSensorTemperatureDepth	The depth at which the pavement temperature is detected

Weather Responsive Systems – Literature Review

	Saturation Flow (decrease)		Free flow Speed (decrease)		Stop Loss (increase)		Max Deceleration
Conditions	Avg	Range	Avg	Range	Avg	Range	
Dry	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	27%g (2.6m/s2)
Wet	5.00%	2% - 7%	5.65%	0% - 8.6%	5.00%	5.00%	27%g (2.6m/s2)
Wet and snowing	9.00%	7% - 11%,	9.03%	1.1% - 13%	5.00%	5.00%	20%g (1.96m/s2)
Wet and Slushy	16.50%	15% - 18%	23.30%	22% - 25%	5.00%	5.00%	20%g (1.96m/s2)
Slushy in Wheel path	21.50%	21% - 20%	29.53%	28.6% - 30%	5.00%	5.00%	20%g (1.96m/s2)
Snowy and sticking	15.67%	11% - 20%	34.65%	34.3% - 35%	36.50%	23% - 50%	20%g (1.96m/s2)
Snowing and packed	13.50%	11% - 16%	38.15%	34.3% - 42%	36.50%	23% - 50%	<20%g (<1.96m/s2)
Temp < -10C		1-8%		1-2%			
Wind >16km/hr		1.00%		1.00%			
Low Visibility (fog)		10-11%		7-12%			

Weather Responsive Systems – Literature Review

The following recommendations are taken from three different studies, one of which is exceptionally well supported and widely cited. The authors recommend that location and weather specific timing plans be developed using the parameters above.

		Recommendation		
Dry		No change		
Wet		10% increase in amber-all-red interval		
Wet and snowing		13% increase in amber-all-red interval		
Wet and Slushy		22% increase in amber-all-red interval		
Slushy in Wheel path		30% increase in amber-all-red interval		
Snowing and packed		42% increase in amber-all-red interval		
lowest friction (black ice)		50% increase in amber-all-red interval		

Questions ??