

# Real-Time Anomaly Detection from Edge to HPC-Cloud

BDEC2, Indiana 2018

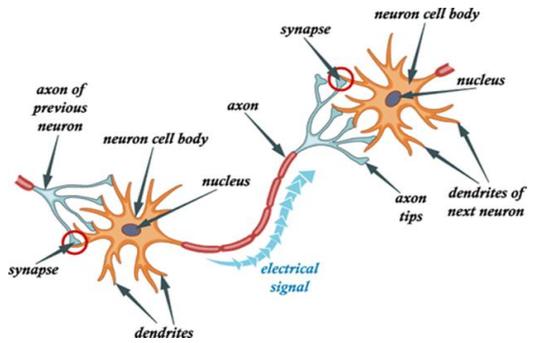
Digital Science Center

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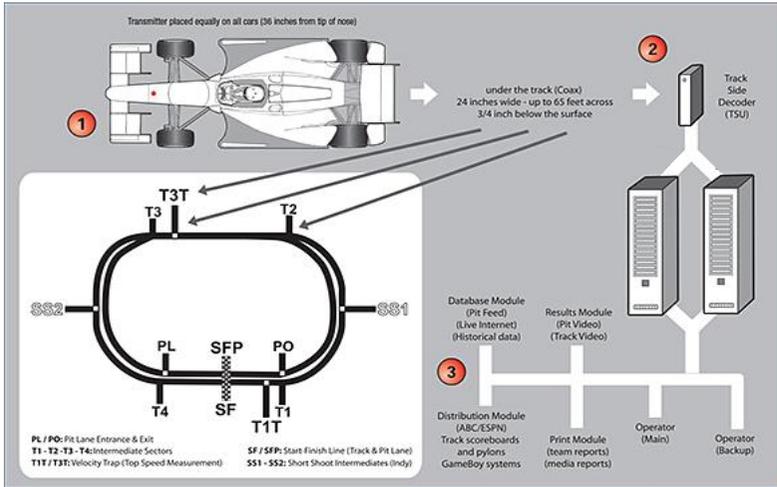


**Real-time applications are challenging, due to strict time constraints and complex computation.**

- The [IndyCar Series](#) is a major open-wheel racing format in North America. The series' premier event is the [Indianapolis 500](#), held each May.
- Computing Systems and Data analytics is critical to the sport
  - improving the performance of the team to make it faster
  - helping the race control to make it safer.
- Topics include Intelligent Apps, AI and Advanced ML, Edge to Cloud, Digital Twins



IndyCar



Command	Count	Protocol	Description	Frequency
A	2052	MLP	Announcement	Every 60 seconds
C	19432	MLP	Completed Lap Results	Upon Event (new and repeated)
D	2652	RP	Invalidated Lap Information	Every 30 seconds
E	7737	MLP	Entry Information	Every 60 seconds
F	725	MLP	Flag Information	Upon Event (new and repeated)
G	7892	RP	Car Display Pit Stop Timer Information	Every 120 seconds
H	17260	MLP	Heart beat	Every Second
I	53	MLP	Invalidated Lap Information	Upon Event (new and repeated)
L	79884	MLP	Line Crossing Information	Upon Event
M	1738	eRP	Messages	Upon Event
N	3861	MLP	New Leader Information	Upon Event
O	33263	RP	Overall Results	Upon Event
P	3693653	eRP	Telemetry Data	
R	701	MLP	Run Information	Every 20 seconds
S	102272	MLP	Completed Section Results	Upon Event (new and repeated)
T	233	MLP	Track Information	Every 60 seconds
U	235	RP	Track Information	Every 30 seconds
V	117	MLP	Version Stream Information	Every 120 seconds
W	287	RP	Weather Data	Every 60 seconds
X	12124	RP	Heart beat	Every Second

Fieldname	Data description	Comments
No	Characters	Car number - 4 characters max
Time Of Day	Integer	TOD in ms
Lap Distance	Float	Metres since start of lap (12345.67)
Vehicle Speed	Float	MPH ie. 123.456
Engine Speed	Integer	RPM ie. 12345
Gear	Integer	0 = Neutral, 1..6 = Gear 1 through 6
Brake	Float	% brake
Throttle	Float	% throttle
Steering	Float	-1.00 .. 0.00 .. 1.00
Long. Accel.	Float	G's - might not be valid for all cars
Lat. Accel.	Float	G's - might not be valid for all cars
Vert. Accel.	Float	G's - might not be valid for all cars
Boost Pressure	Float	Turbo boost pressure
Tire Type	Character	P = Primary A = Alternate W = Wets U = Unknown

## Timing and Score Data

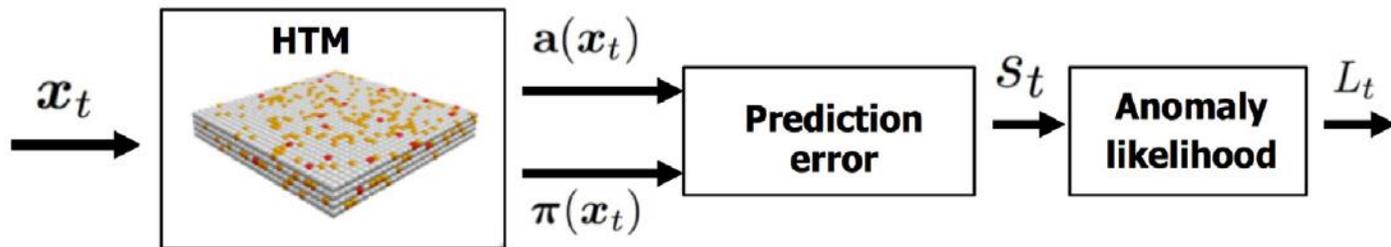
- Sensors in the cars and under the track.
- Antenna and communication system.
- Telemetry data (including the many performance information of the cars like speed, gear, brake, throttle, etc) stream into the on-site computer system in a real-time fashion.

## Dataset

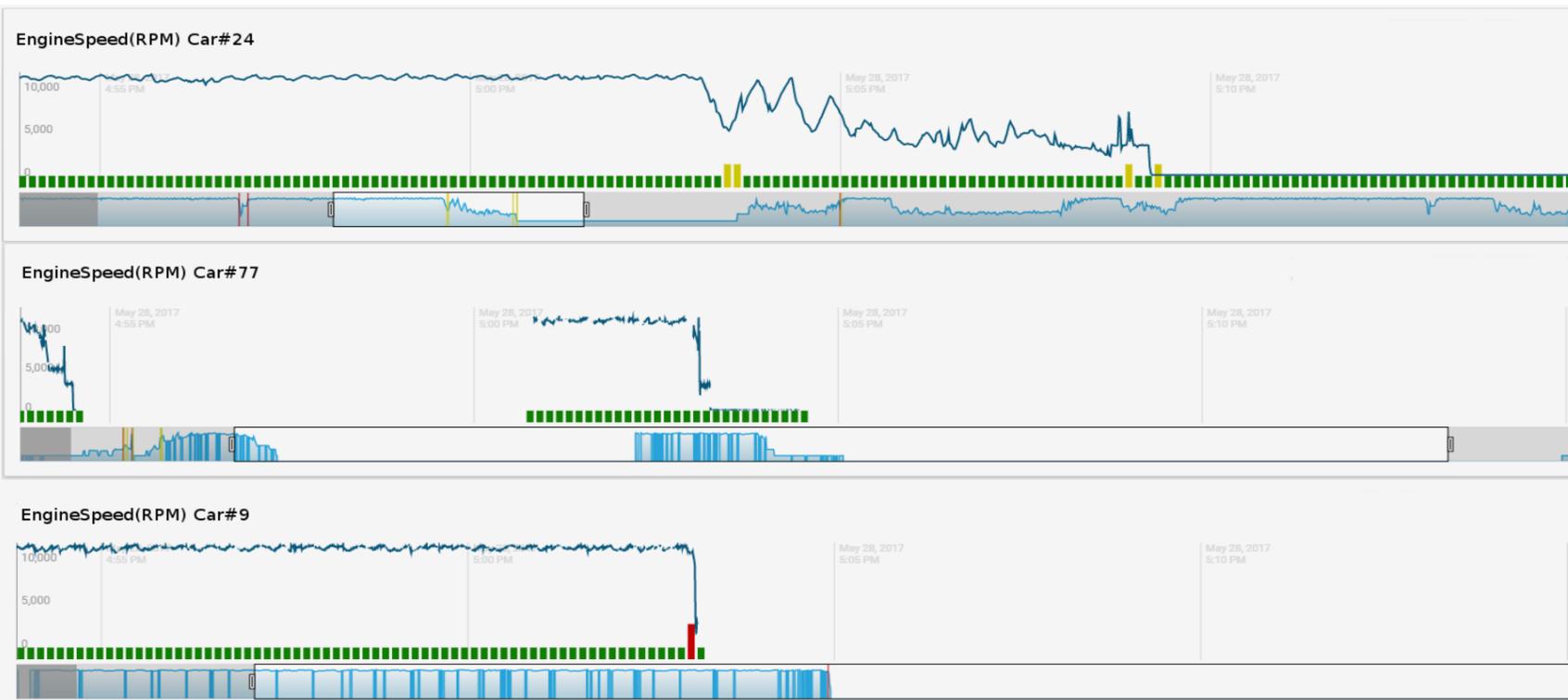
- The INDYCAR Timing system supports retrieving timing data from the primary timing system – serial or sequential data feed for live data and report querying for historical or archived data.
- The **Results Protocol** is designed to deliver more detailed results information through the use of a single record command.
- Example: one Indianapolis 500 car race on the 28th of May 2017 which contained 750 MB of data and total of 3986170 records.

## Telemetry Data

- Telemetry is a radio device that relays information such as engine, tire, steering and throttle performance to team engineers in the pit box. The team can monitor car and driver activity to ensure the car is performing properly.
- During a race, IndyCar Series teams use telemetry to gather data live from the cars as they formulate their race strategy. In the IndyCar Series, teams receive their data from their own on-board systems as well as from the league's Timing & Scoring operation.



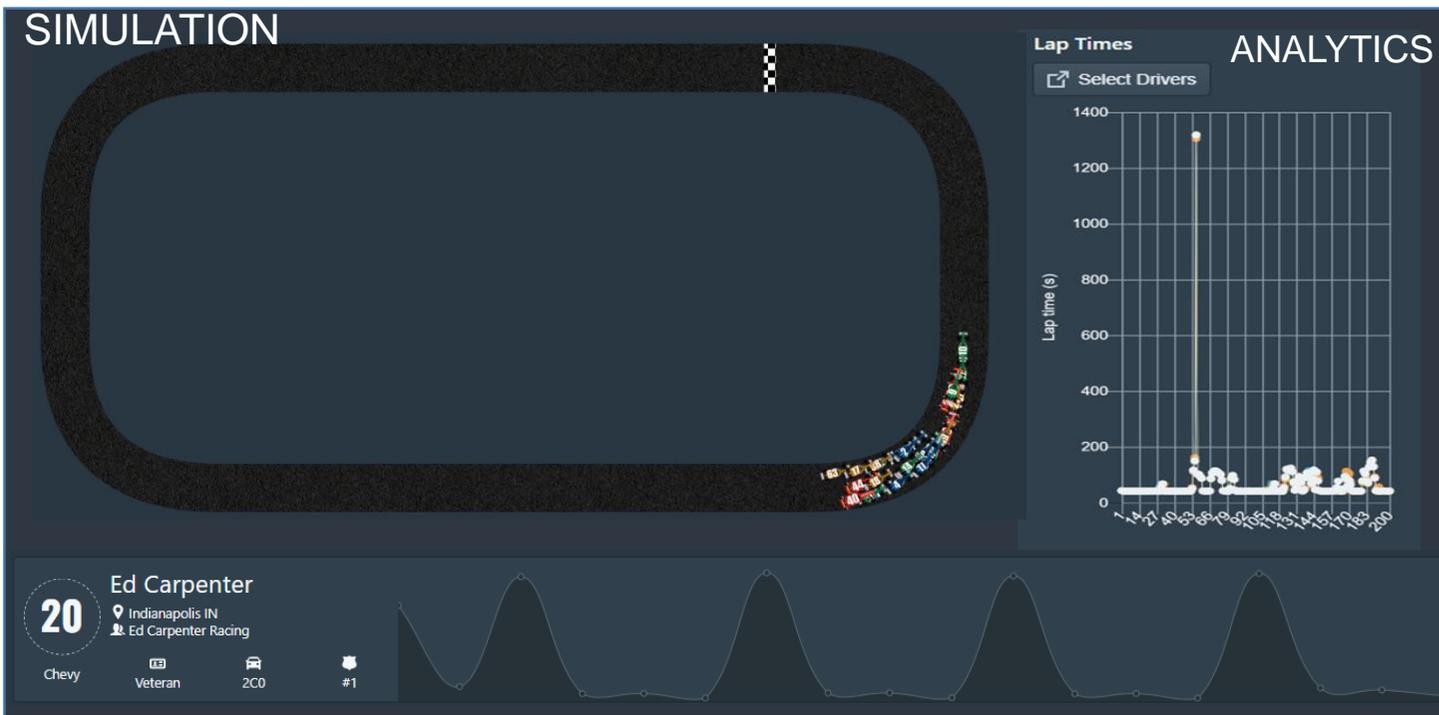
- Hierarchical Temporal Memory (HTM) is an online machine learning technology that aims to capture the structural and algorithmic properties of the neocortex.
- The anomaly occurs around 15:03 pm, where the RPM of car #9 totally disappeared. In fact, car #9 got totaled due to a collision with car #77. The other cars, including car #24, all slowed down after the crash.



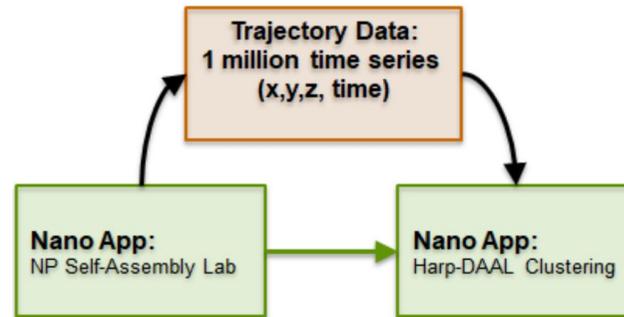
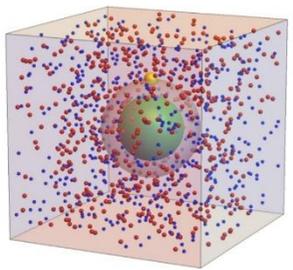
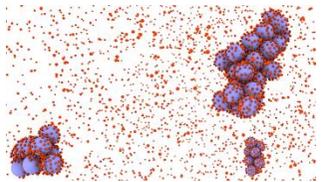
Correlation of "events" among different cars: #9 #77 and #24



# Anomaly Detection and Correlation Analysis



- Simulation or replay of the racing event with on-the-fly analytics
- Accelerating the process of clustering the nanoBIO simulation results to obtain different nanoparticle trajectories.
- NP Self-Assembly Lab simulates assembly of nanoparticles and generates 1 million high dimensional trajectory data. Harp-DAAL takes the input data and runs clustering over different nanoparticle trajectories that can be visualized for NP distribution.



# Simulation and Time-Series Analysis for IndyCar and Nano Applications