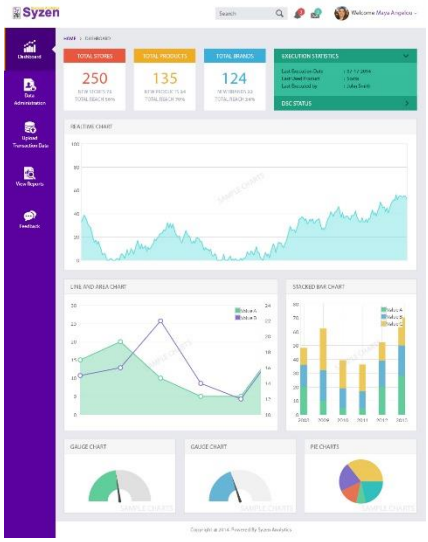
Usher Syndrome in IoT – and a Cure

Have you ever seen an IoT dashboard that **does NOT look like this?**



What you are seeing are many channels of measurements that flow into this IoT system displayed on individual charts, graphs and numbers . . . this is like Usher syndrome in human vision! Those with Usher syndrome see the world as looking through a straw – one narrow view at a time. It is extremely disconcerting to the patient (and worse, degeneration can be progressive).

Clearly, for human beings seeing the full picture and the interconnections – the BIG picture, as it were – is supremely important. *IoT if no different* . . .

Multiple channels of data that flow into an IoT platform need to lead to a FULL picture to be able to extract maximum information from your expensive IoT installation. Focus is on ALL the IMPORTANT information . . .

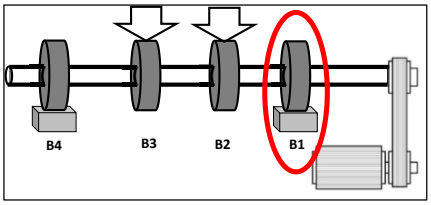
Today's IoT suffers from Usher syndrome! Single channel data – raw or aggregated – appear on dashboards. People try to make sense of it – some do but miss most of the INTERACTIONS among the many channels that we make available to them. There was a time when this situation was acceptable . . . dashboard was the be all and end all. Not anymore . . .

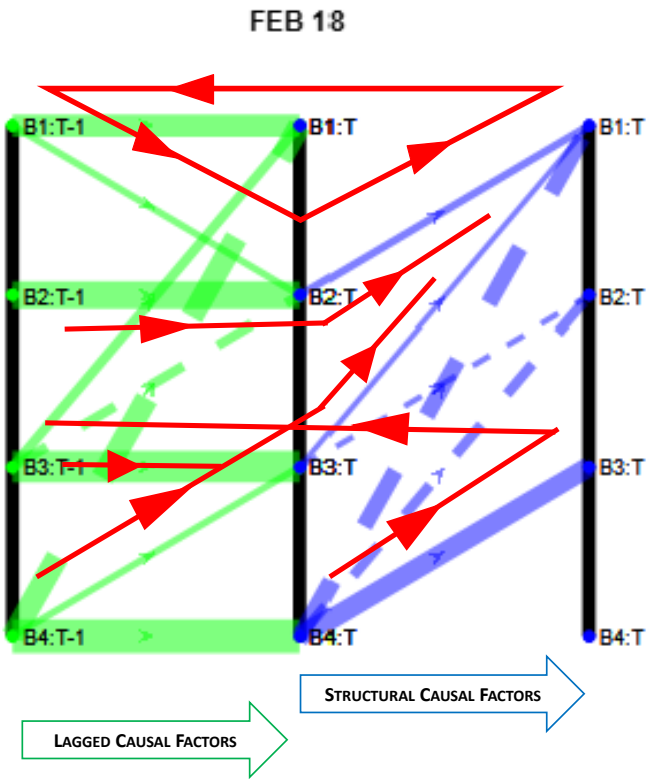
Human cleverness is not enough to extract inter-channel interactions just by looking – it falls in the category of a very difficult inter-channel cause-effect estimation problem.

Multi-channel IoT time series can be treated as a vector time series. Vector time series at each sampling instant are temporally correlated to past samples; if we think of each channel as a "node" in a causal graph, we can call the causal factors among them as "self-node" and "inter-node" **lagged** causal factors. Also, if you take a snapshot at one time instant, there will be cause-effect relationships among the elements of the vector time series which leads to "inter-node" **structural** causal factors.

In IoT technology, lagged relationships are fairly well-understood but not yet in a “Causality” way. Structural causal factors are virtually UNKNOWN. Now that IoT is reaching puberty, it is time we started using lagged and structural causal factors that RELATE various single channels in a multi-channel measurement - causal factors are revelatory!

Here is a simple example. We had developed a very efficient solution to extract the lagged and structural causal factors and demonstrated its application in a bearing system test (4 bearings as shown on the left).





Without going into a lot of details, the causal factors are best displayed on a “Ladder graph” as shown on the right. One day before (Feb 18) Bearing, B1, failed, the green and blue arrows show the lagged and structural causal factors.

To make the hitherto-unavailable multichannel insights visible, I have overlayed the RED arrows showing how Bearing, B1, becomes the end effect of many causes that increase its vibration energy. *The red triangle (inverted) at the top is very problematic* – it is a positive feedback loop with “run away” destructive possibilities! No wonder B1 failed the next day! More importantly, a machine dynamics expert can take look at this and immediately see how the bearing spacing, shaft stiffness, damping, etc., should be altered so that such a failure will not happen again. Additionally, the changes planned can be explored by adjusting the causal factors on the Ladder graph to see exactly how the conditions change – *NOTE that this is possible ONLY if you have the causal picture and not a “correlation” picture*.

All the technical and application details are available in “**A step change in IoT ML - Ladder graph Causal Digital twin**” at https://www.linkedin.com/pulse/step-change-iot-ml-ladder-graph-causal-digital-twin-dr-pg-madhavan and related publications.

Applications are many. Wherever there is IoT data as multi-channel time series, our Causal Digital Twin can be applied for causal discovery and causal estimation to achieve significant operational objectives as the examples below show.

Consider the following IoT use cases that generate multi-channel time series:

1. A manufacturing plant production line with a set of machines with connected sensors; **OBJECTIVE: Increase Production**
2. A building with monitoring data from HVAC system, occupancy, lights and computer operation, water usage; **OBJECTIVE: Minimize energy usage**
3. A retail store that monitors shelf facings, back-room store, shopper density, POS terminal data; **OBJECTIVE: Reduce OOS (out-of-stock) problem**
4. A smart city operation where multiple feeder road traffic and major intersections are monitored in real-time; **OBJECTIVE: Real-time traffic engineering to minimize congestion at the intersection**

IoT technology is now ready to go beyond "looking through straws" and extract the FULL picture to help our clients improve productivity and quality as well as reduce waste, thus increasing gross margins.

Best regards, PG

Dr. PG Madhavan

Seattle, WA

https://www.linkedin.com/in/pgmad/

#IoT #Multichannel #Causaldigitaltwin #Laddergraph #StructuralCausalFactors