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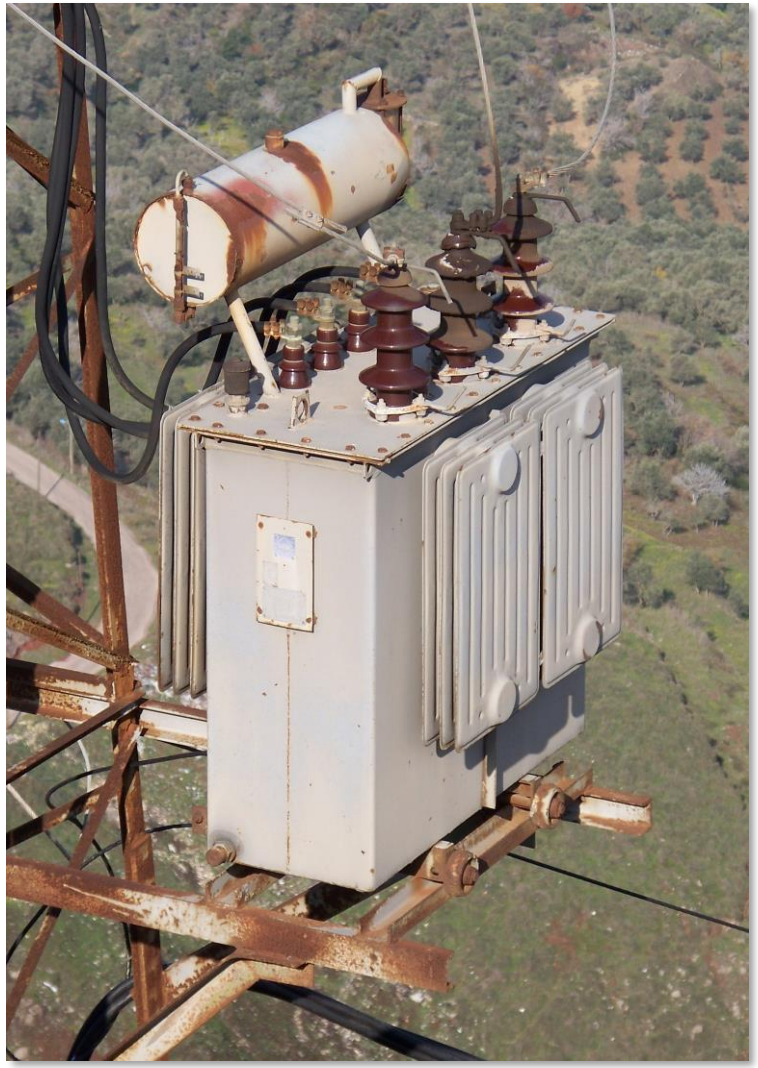
Health Monitoring for Distribution Transformers

What are distribution transformers?

- Handle < 200 kVA power
- Usually step-down from 10-30 kV to household voltages (230V)
- Responsible for delivering electricity to residential/industrial establishments
- Close to 25 Mio units in India alone



What does a distribution transformer look like?

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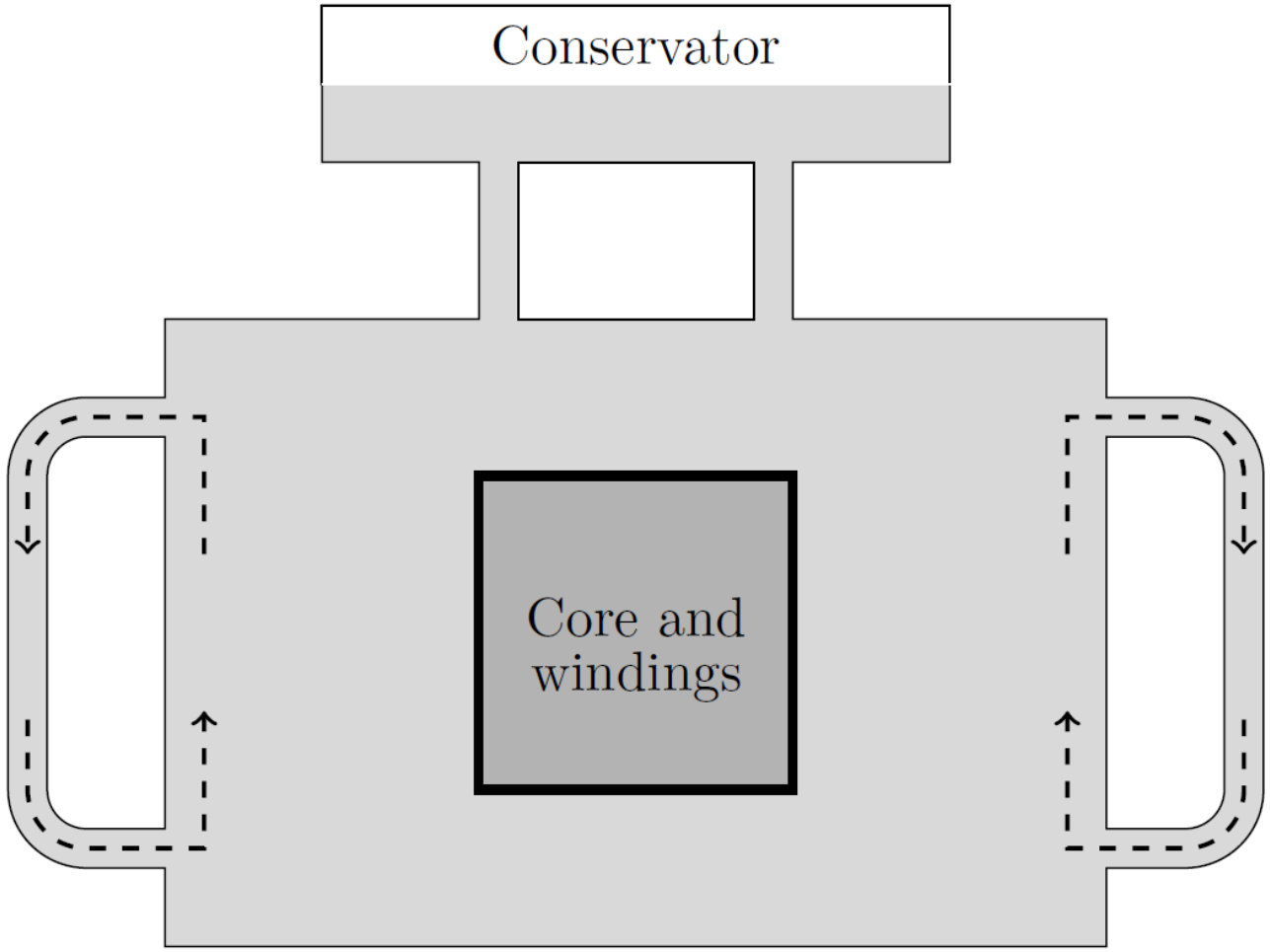
- Heat generated in transformers carried away by thermally conducting oil
- Prevention of over-heating prolongs the life of the transformer
- *Arc*-ing avoided by electrically insulating oil
- Inhibition of arc-formation prevents catastrophic failure of transformers



Why do we need to monitor oil-level in transformers?

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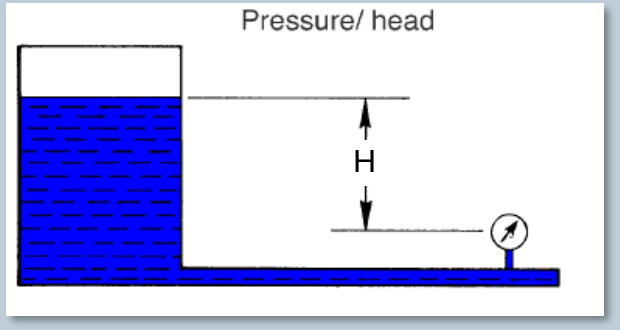
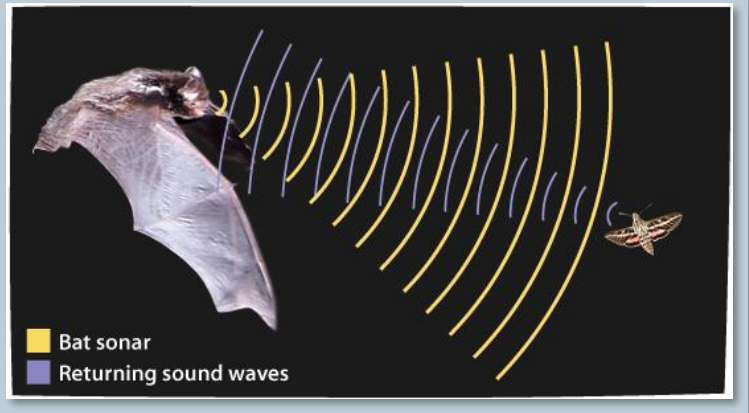
- Older transformers develop cracks in t
- Weakened joints a lead to leakage of
- Steady decrease i deteriorates the eff transformer
- Unattended leaky t can pose a danger property

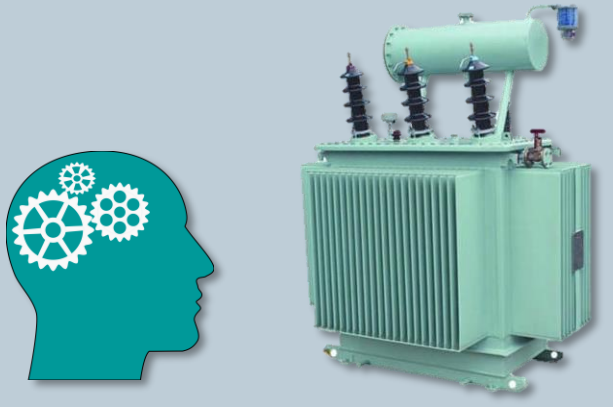
How can we monitor oil-level in transformers?



- ☺ Accurate estimation of oil-level
- ☹ No inbuilt pressure sensors
- ☹ Not possible to retrofit pressure sensors in 25 Mio units



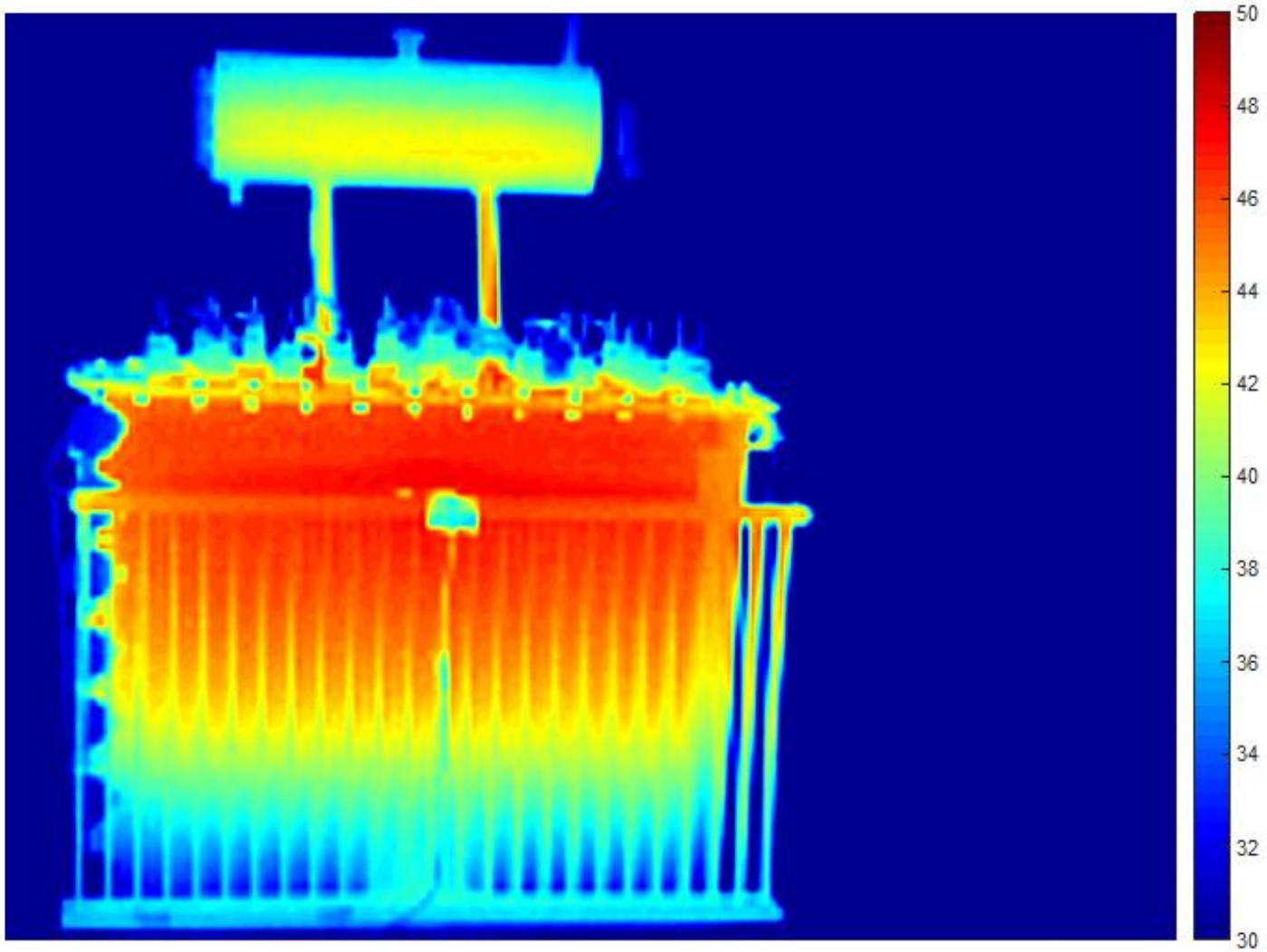
- ☺ Accurate estimation of oil-level
- ☹ Expensive sensors



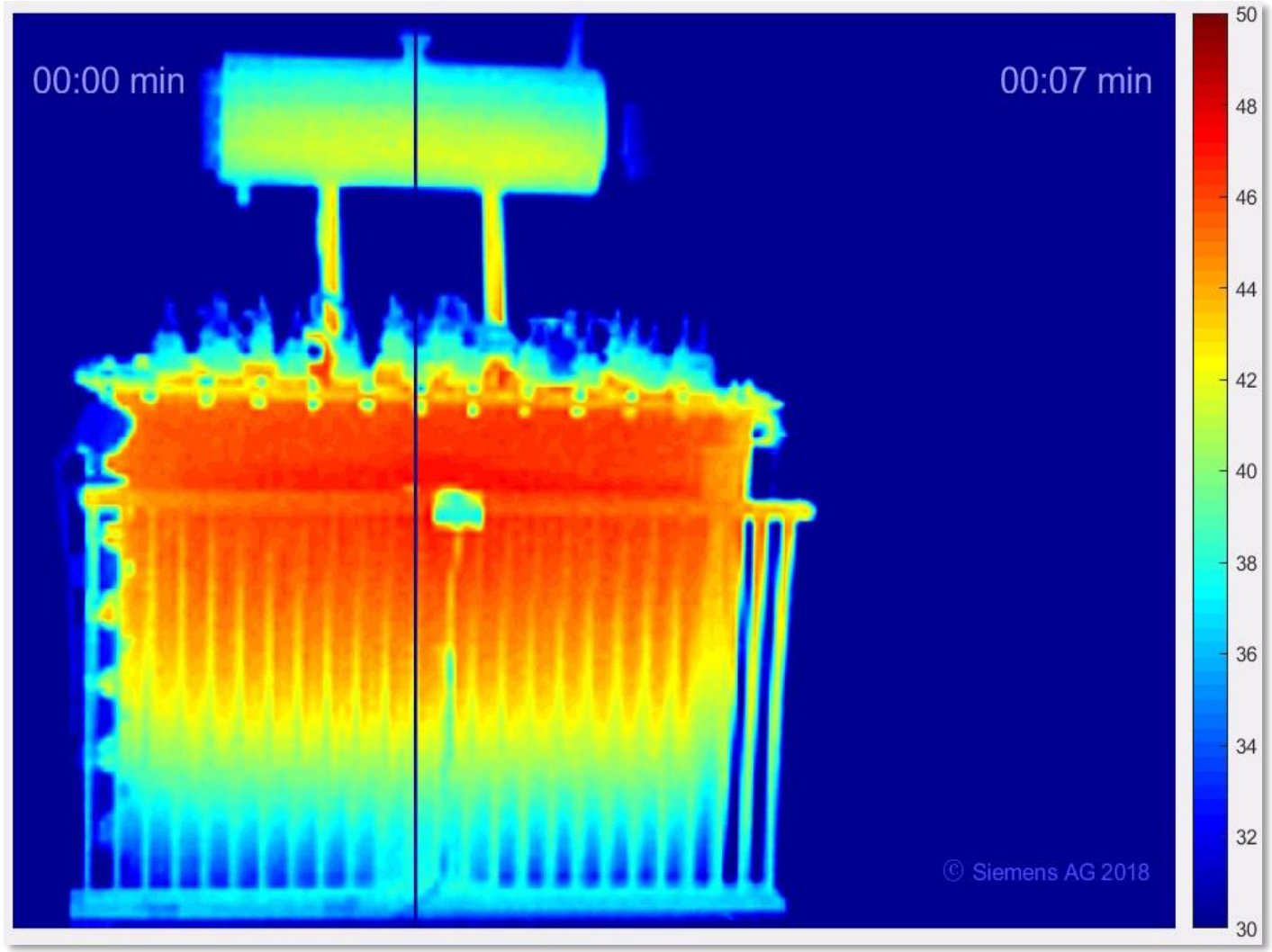
Implementing the concept of **virtual sensing**, we can indirectly measure oil-level using readily measurable quantities

Non-invasive measurement

Using the concept of convective heat transfer to estimate the amount of oil in a transformer tank



How does the oil-temperature change when part of the oil is drained?



- Oil drained completely from the overhead tank (conservator) at **5 minutes from the start** of recording
- Power of the transformer held constant
- Video shows comparison of oil temperatures in the tank before and after draining the oil from the conservator

The same equations have the same solutions

- Richard P. Feynman

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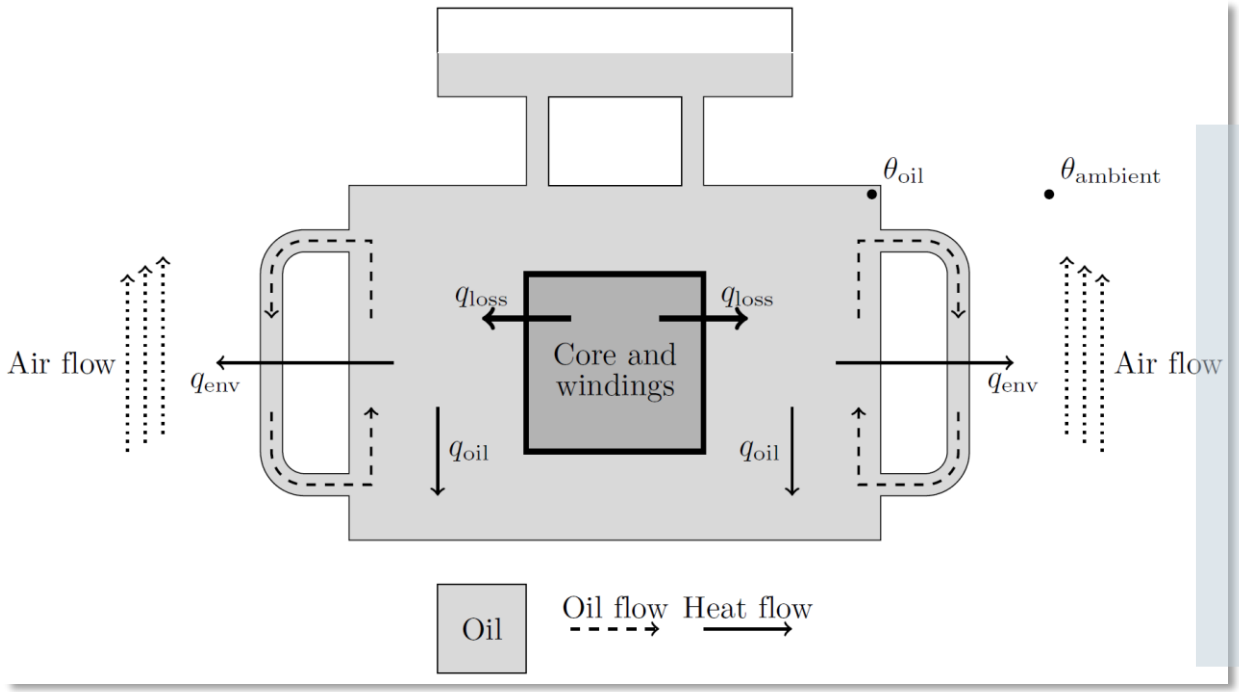
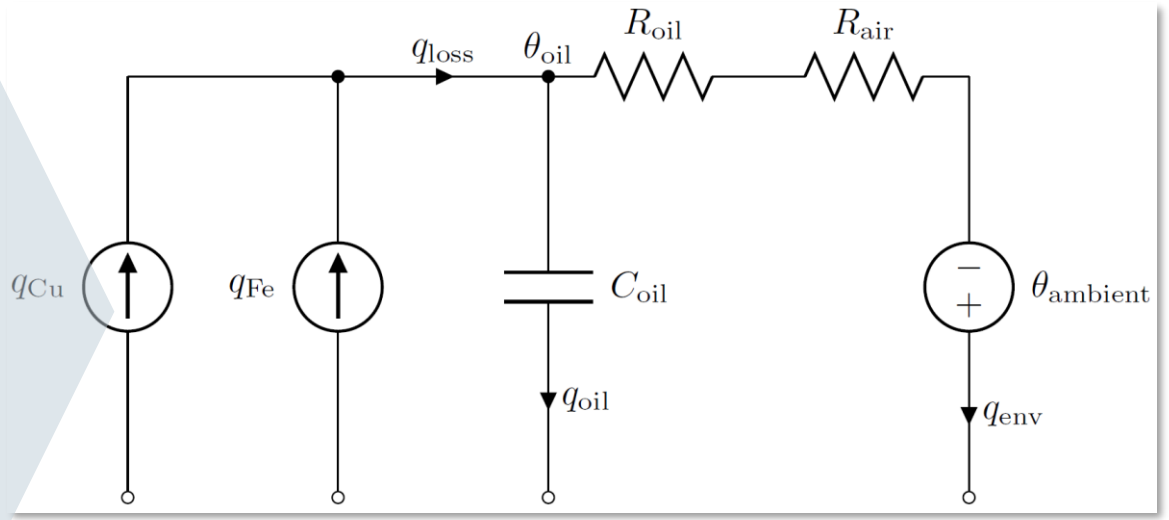
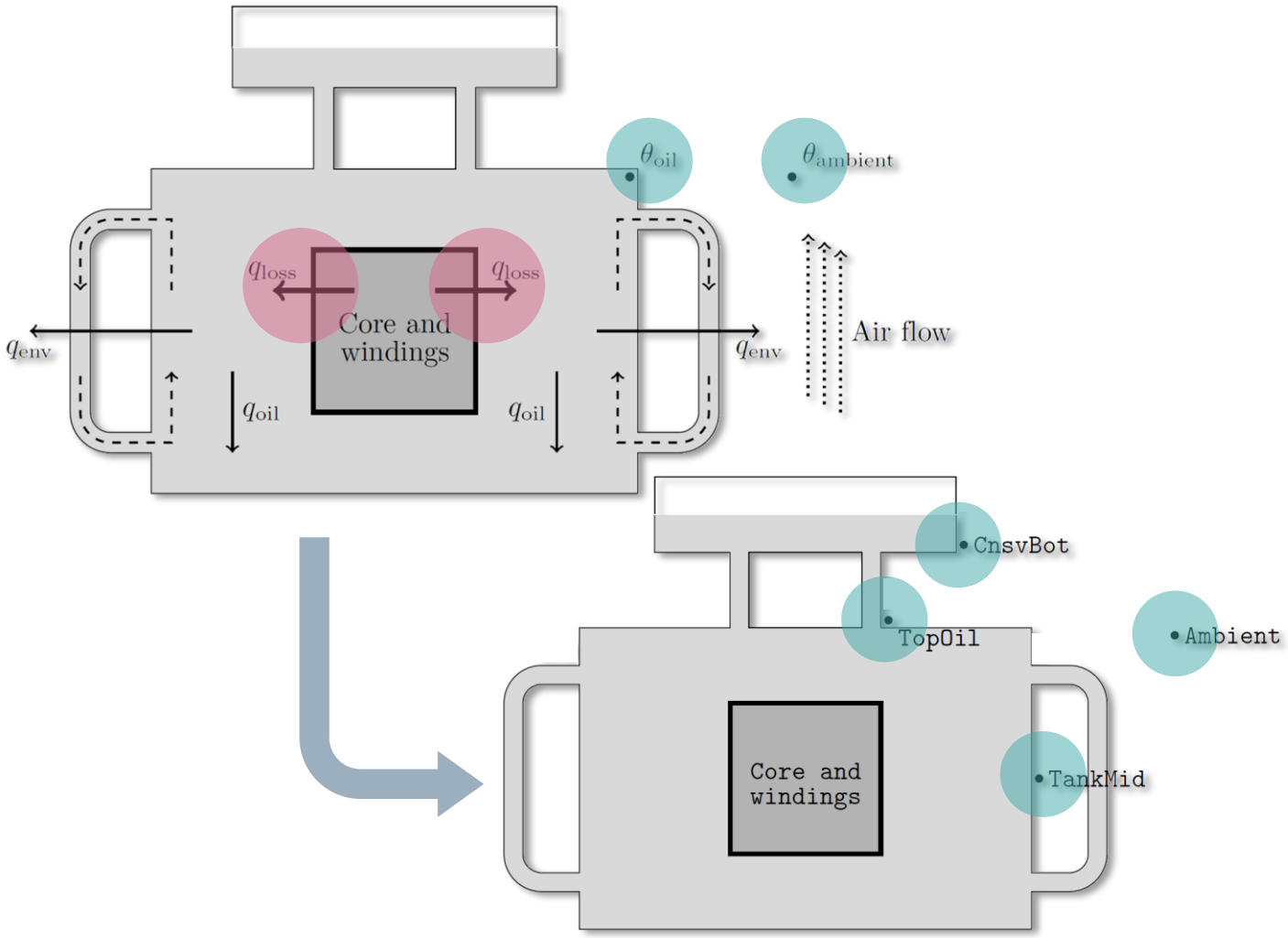
Thermal model of a transformer



Analogous Electrical Equivalent



Physics meets Data

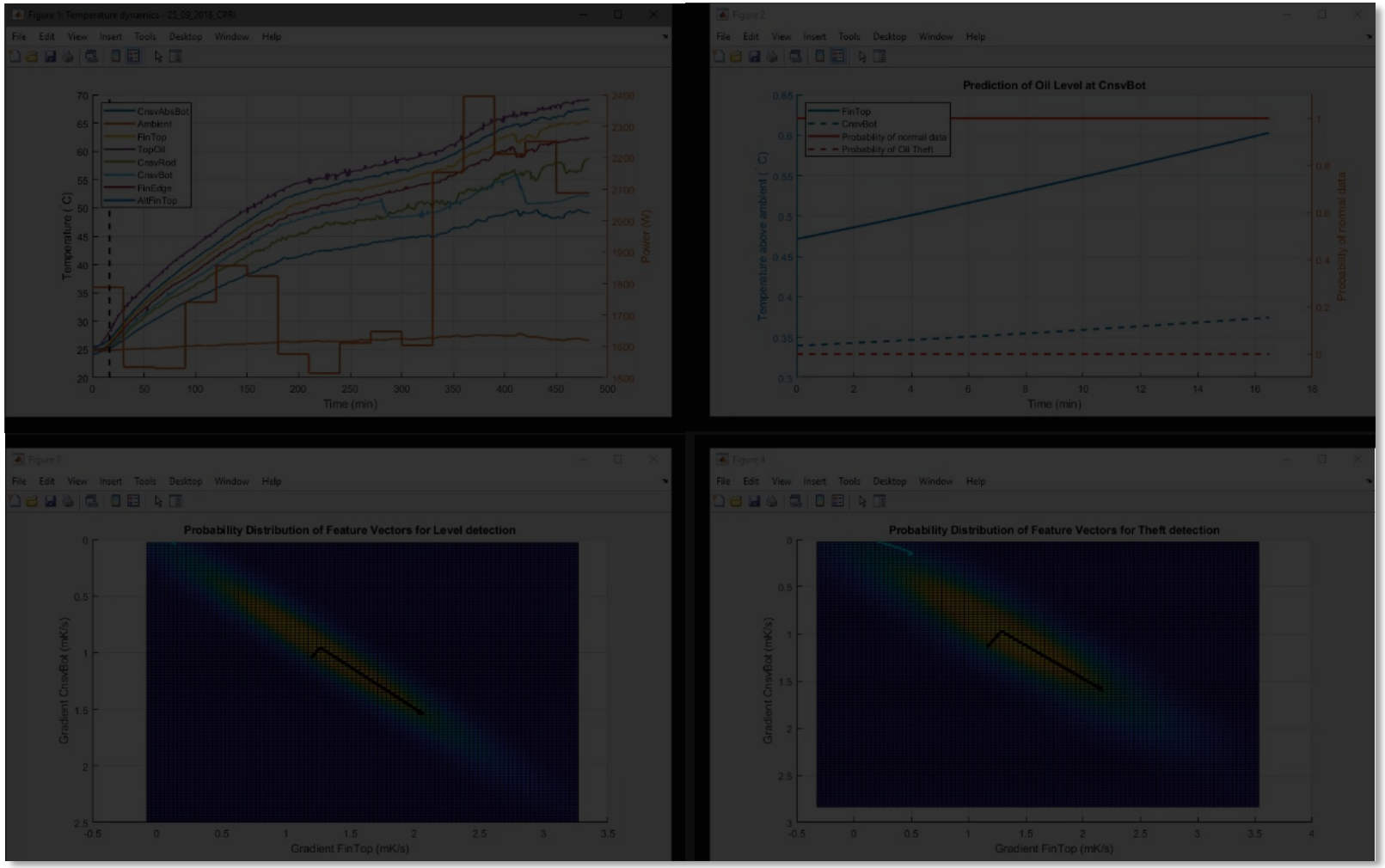


- Power measuring sensors (direct/indirect) very expensive
- Using correlation of temperature measurements at various locations on the transformer tank as an alternative to power measurement
- Statistical correlation algorithm developed based on findings from the thermal model

Temperature sensor

Voltage/Current sensor

Prediction of oil-level and oil-theft based on temperature correlation



- Power loss measurement only for reference
- Theft-detection designed to be extremely reactive to thefts
- Oil-level detection designed to maximize sensitivity and specificity

Patent filed

Spherical chicken in a vacuum?

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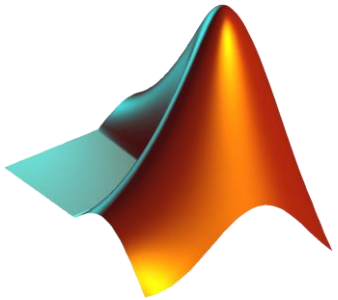
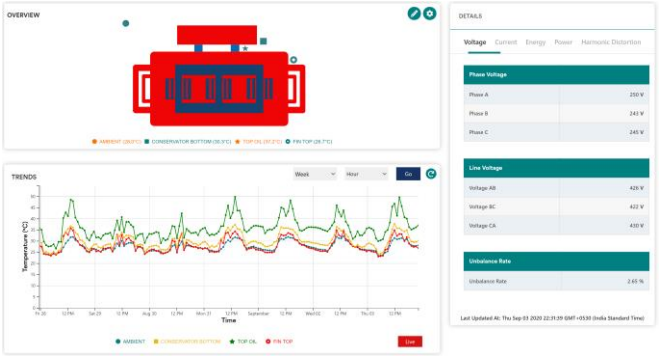
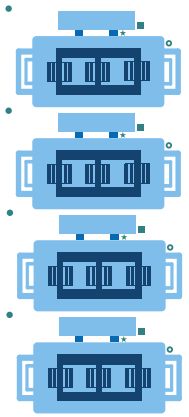
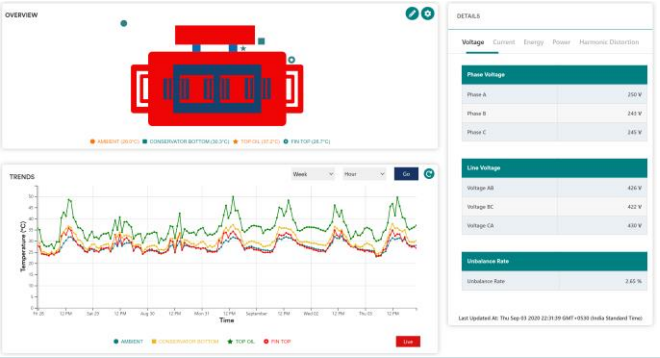


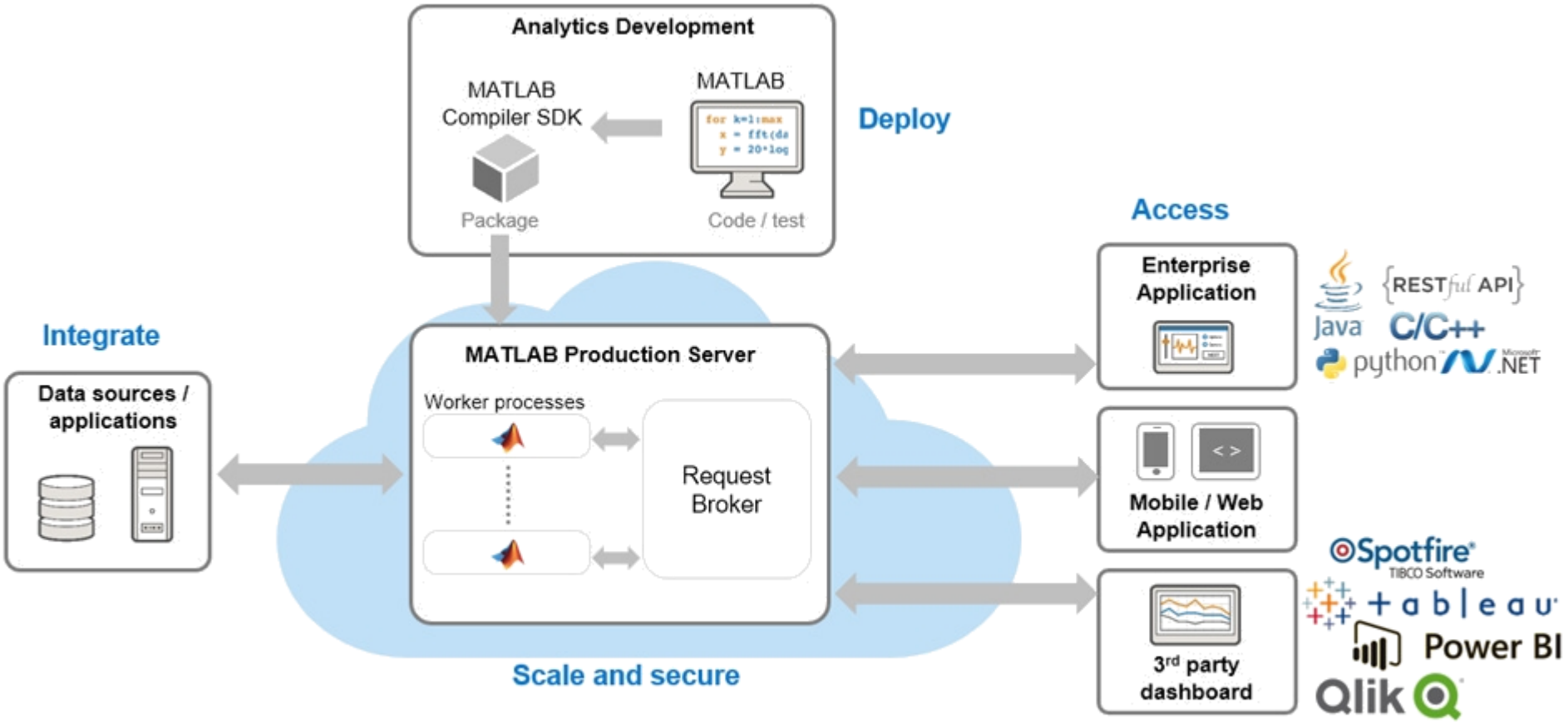




Real-time analytics

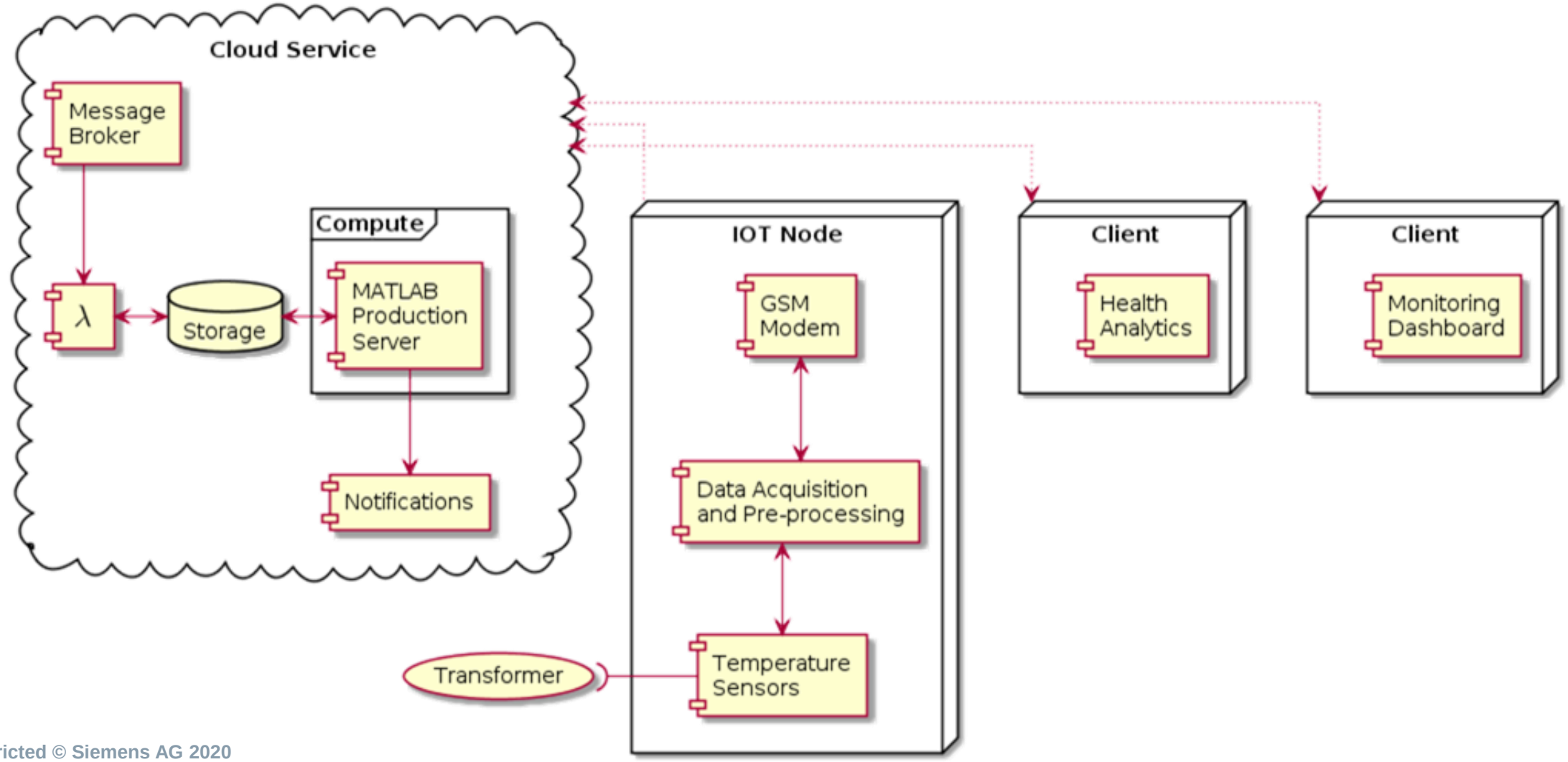


MATLAB Production Server: Bridging the gap between ideas and deployment



Picture credits: MathWorks

Field deployment of the solution



Validation of the algorithm on the field

- Temperature sensors along with data-acquisition systems installed on live transformers on the field
- Acquired data used for fine-tuning of the algorithm
- Targeted testing also done in a government certification lab to capture corner cases
- *Algorithm could successfully predict low oil-level on a live transformer on the field*

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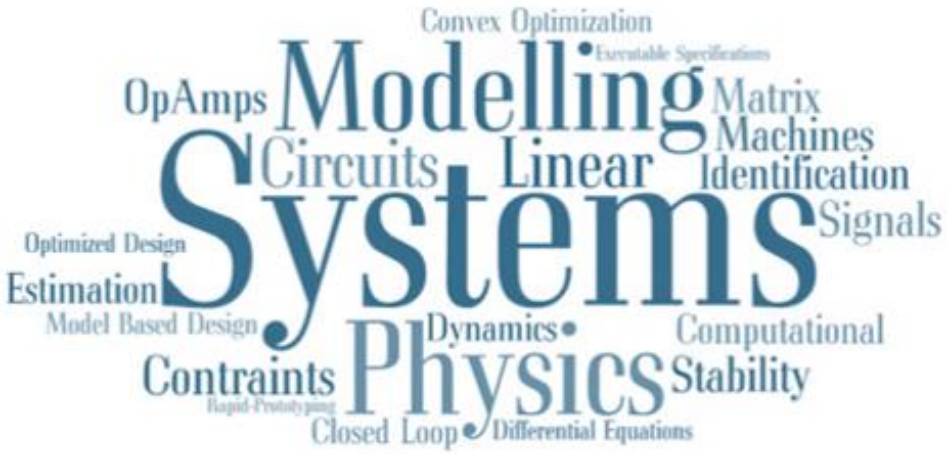
Application Demo

Contact Information



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