Technology, Application, and Standardization for OpenADR in Japan

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Contents

1. FastADR of Building Air-conditioners

2. Research on FastADR Aggregation

3. OpenADR Standardization in Japan

Office Building Air-conditioners in Japan

- Variable Refrigerant Flow (VRF) building air-conditioners are very popular for office buildings in Japan.
- Approximately 1.5 million VRF air-conditioners are installed in 140 thousand buildings all over the country.
- Grand total of rated power consumption is estimated 15GW.

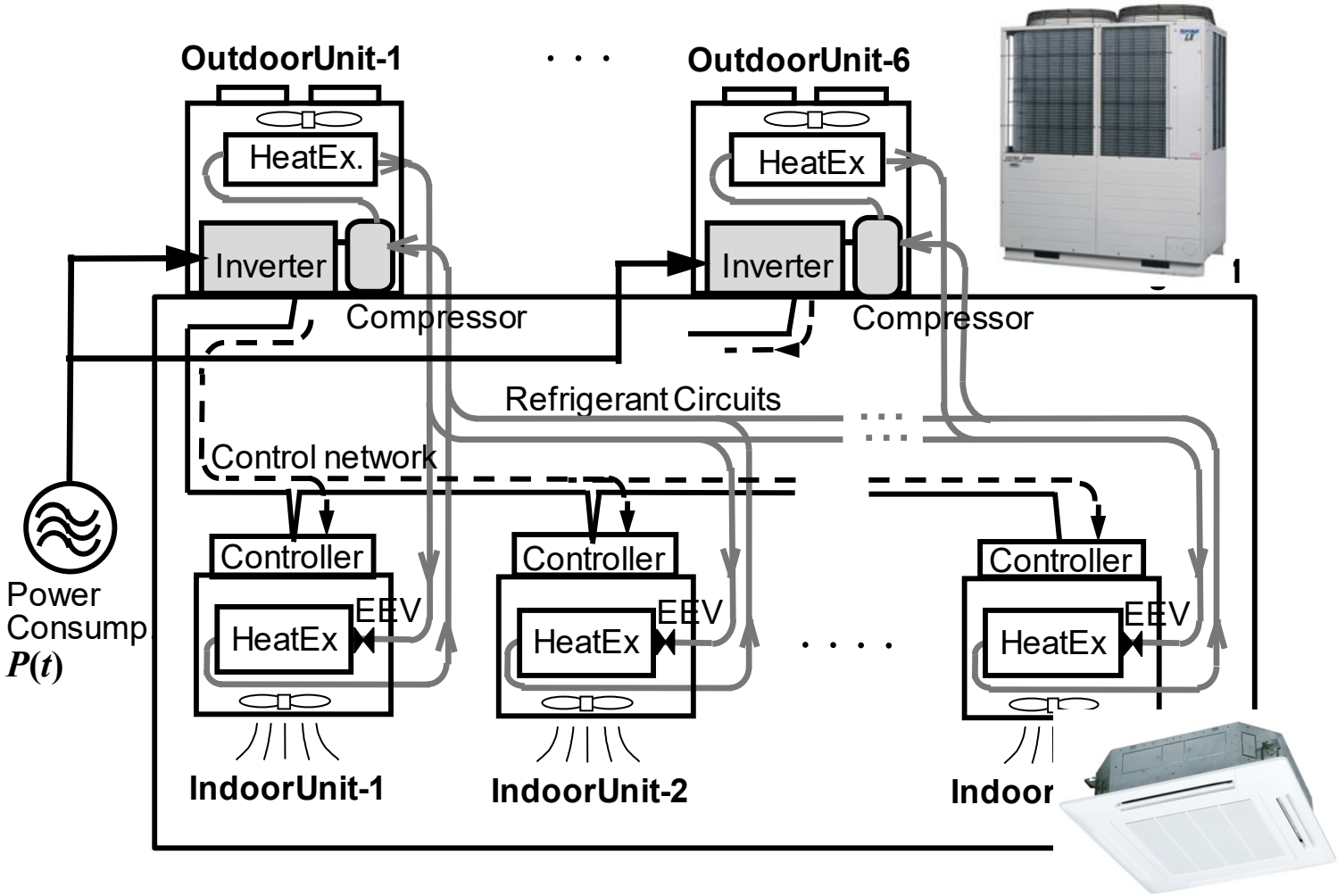
A typical 10- story office building

Outdoor units on the roof

Indoor units embedded in the ceiling

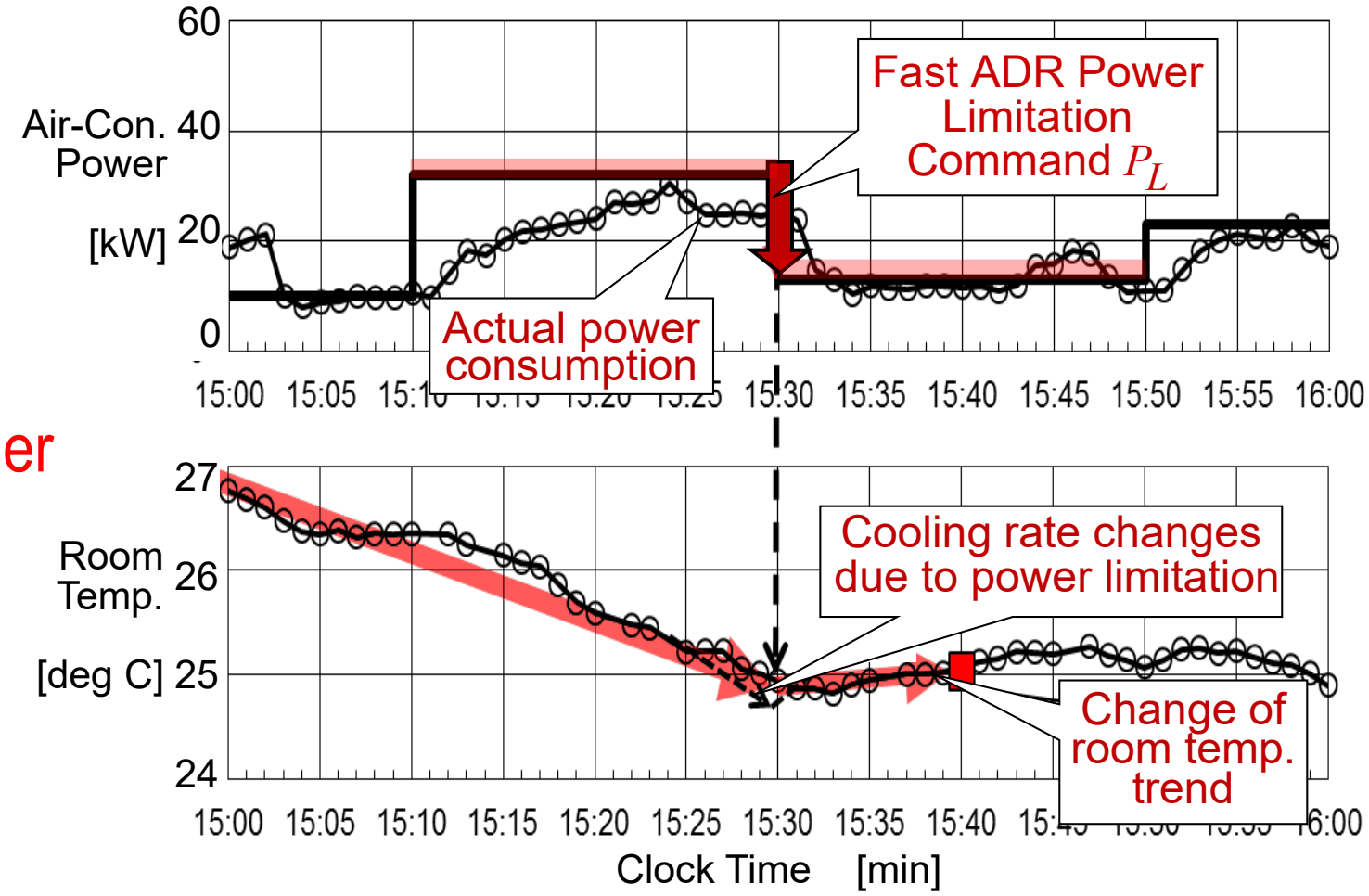
Controllable Inverter-Driven Refrigerant Compressor

- Each outdoor unit has inverter-driven compressors that supply refrigerant gas to indoor units.
- Approximately 90% of power is consumed by the compressor.
- Compressor power can be controlled by the inverter in an exquisite way instead of a primitive On/Off way.



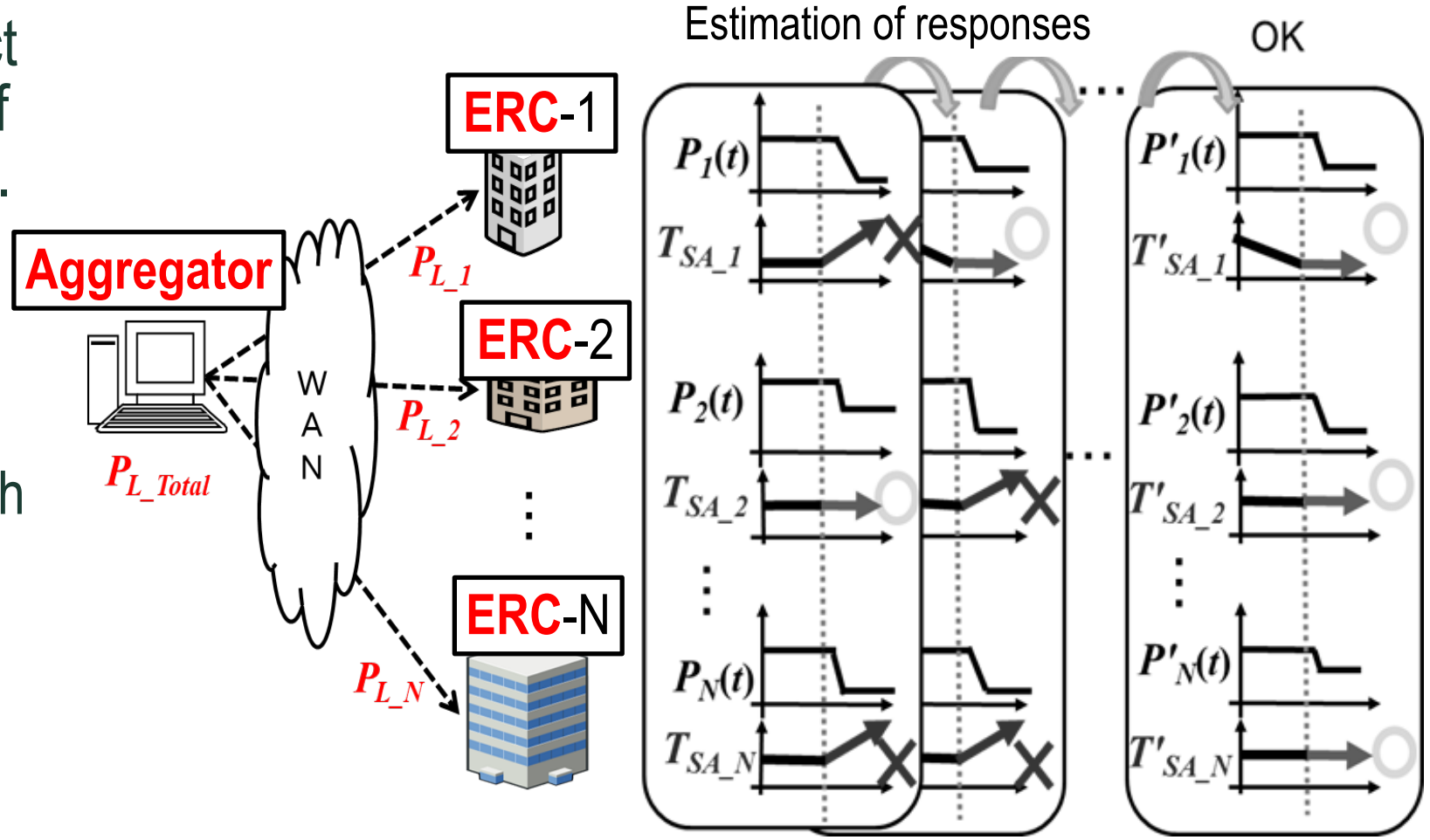
Power Limitation Command for FastADR of VRF Air-Cons.

- Fast Automated Demand Response (FastADR) will be realized with the Power Limitation Command P_L
- An Aggregator sends P_L and an Energy Resource Controller (ERC) controls each inverter.
- The most important problem is the prediction of each air-con. reaction.



FastADR Power Limitation Command Allocation

- Each air-con. would react stochastically because of each operation condition.
- It is a tough task for the Aggregator to allocate limitation commands $P_{L\_1}, P_{L\_2}, ..., P_{L\_N}$ to each ERC-1, ERC-2, ..., ERC-N
- However, we can expect an averaging effect by a large-scale aggregation



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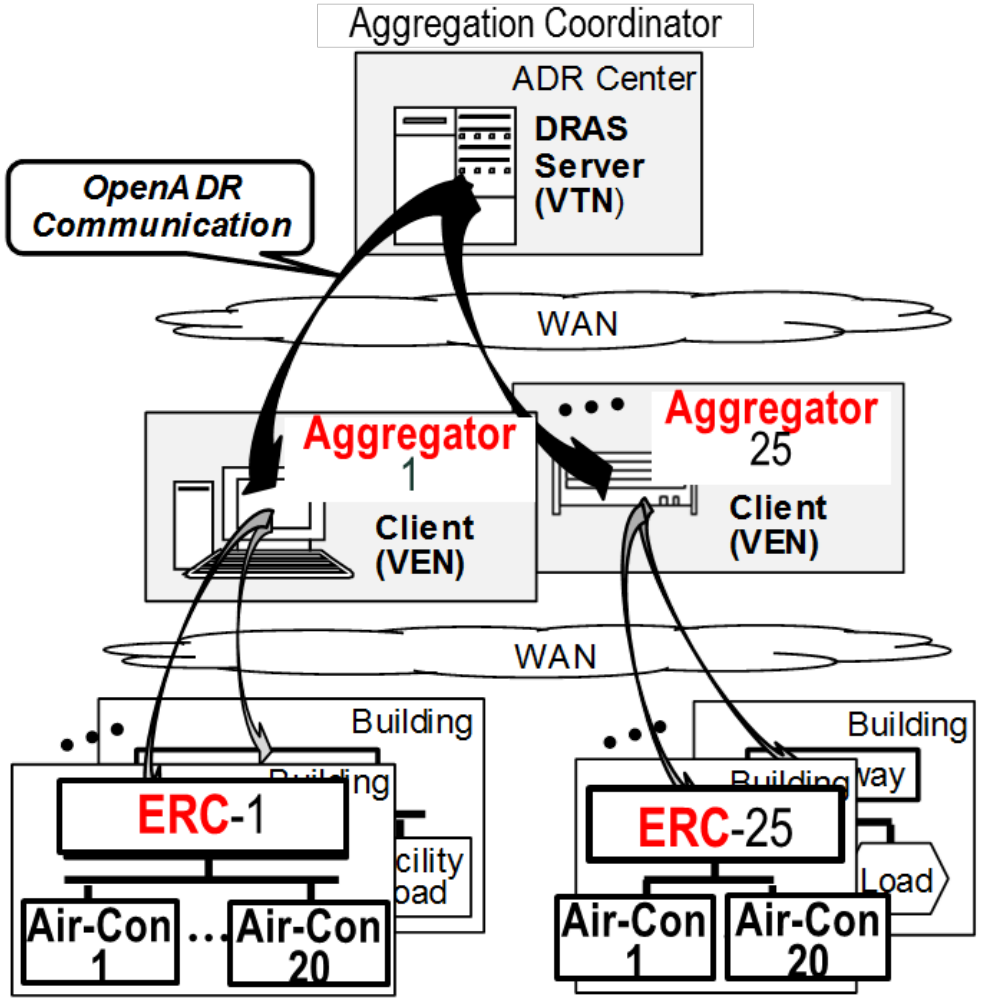
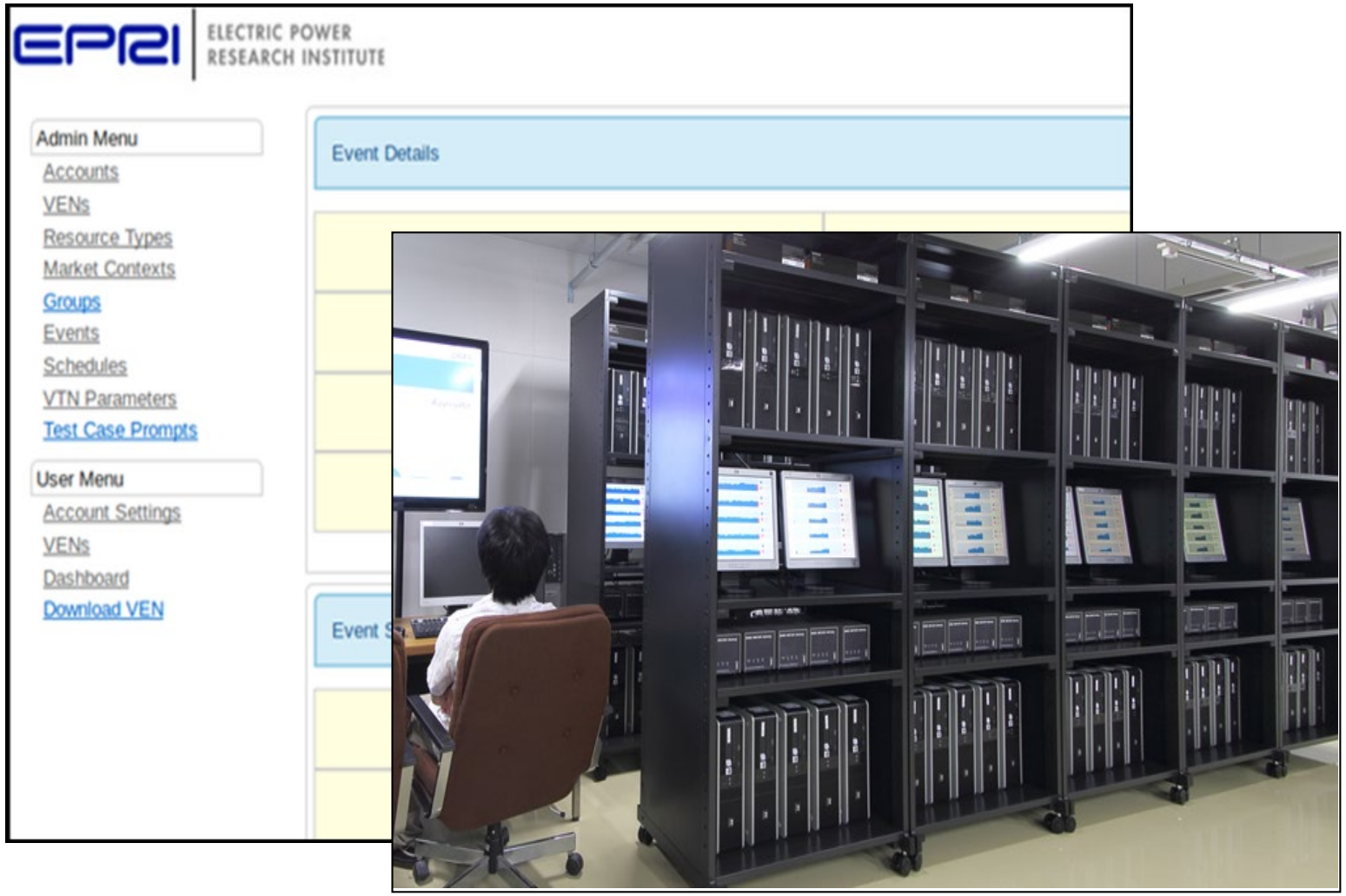
Research on Large-scale FastADR Aggregation

- A large number of office building air-cons make the FastADR meaningful.
- We assume 25 Aggregators, each has 20 office buildings with an ERC and 20 air-cons.
- Target Negawatt is :
  -2 kW x 20 air-cons.
  x 20 buildings x 25 AGGs
  = - 20 MW



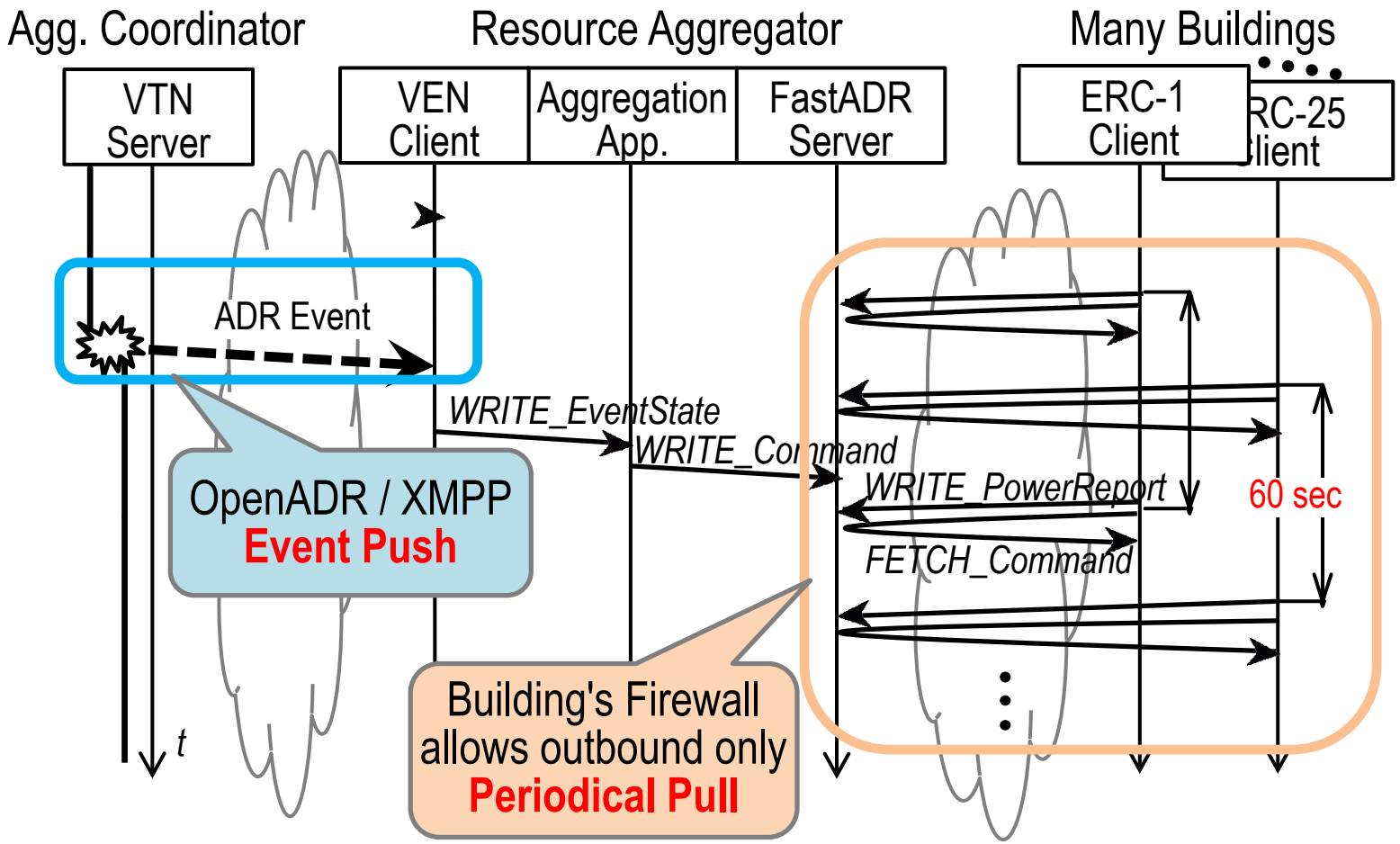
Realistic FastADR Aggregation Simulator in Our Lab.

- The simulator has an Aggregator and 100 real-time air-con emulators.
- The EPRI's demo DRAS server is installed
- Network communication delays are emulated by "Dummynet."
- Actual OpenADR messages are actually transferred over XMPP.



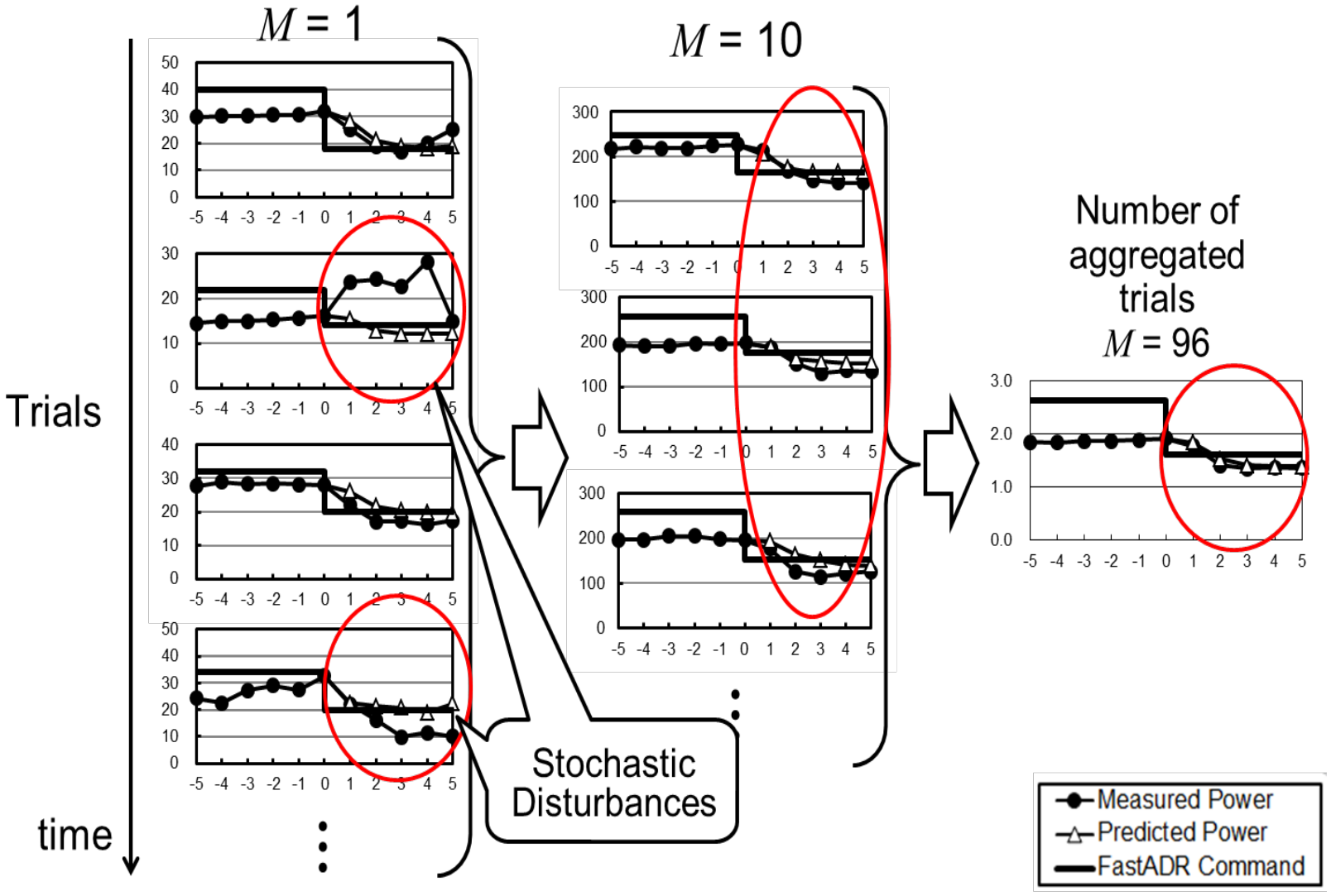
Communication Model of FastADR Aggregation

- OpenADR messages are transferred from the VTN server all the way to each gateway of building emulator.
- IEEE1888 web service standard is used for FastADR power limitation command from the Aggregator to the ERC.



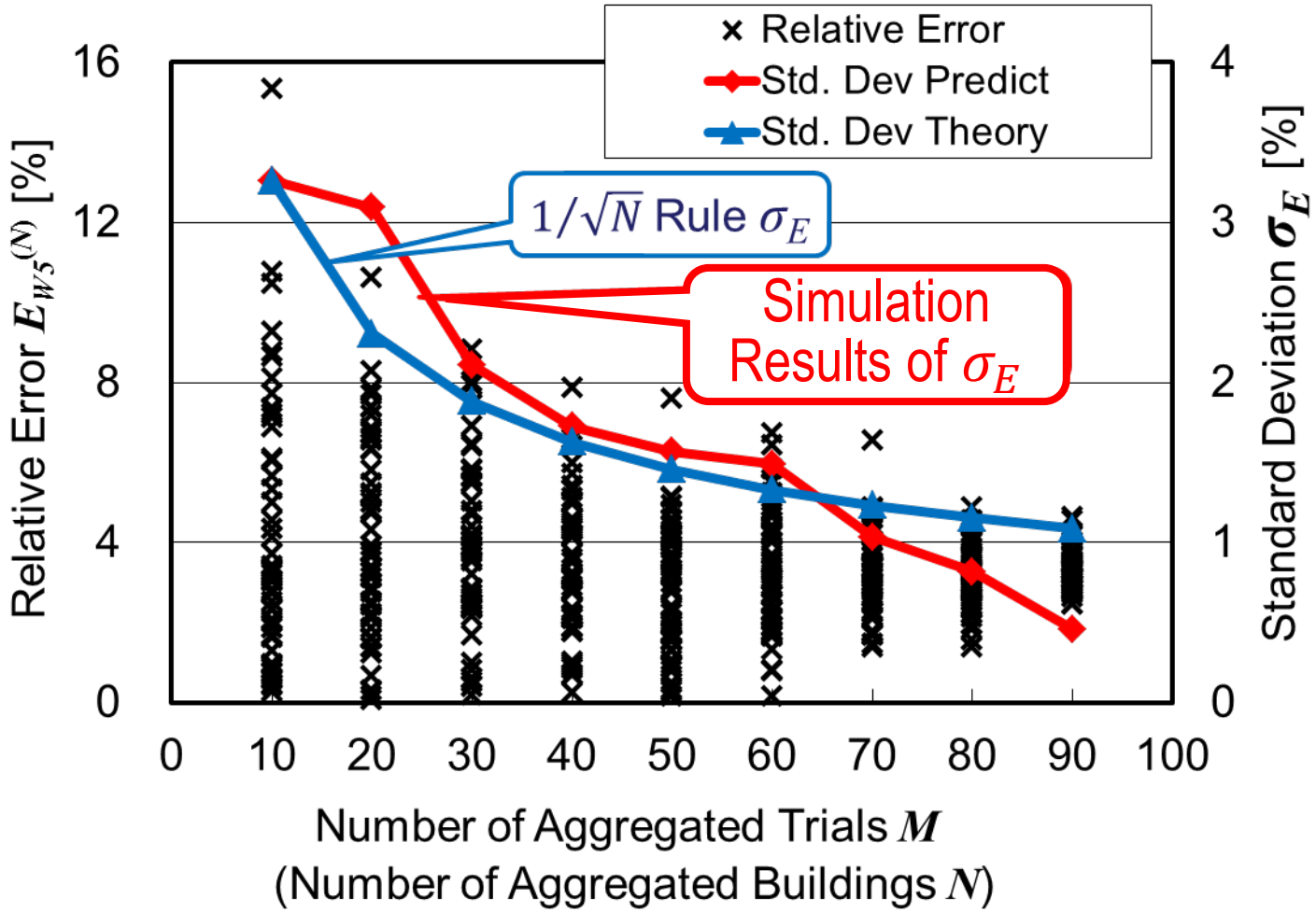
Simulation Result of Aggregated FastADR Power Reductions

- Our air-con emulator's behavior varies one by one and trial by trial.
- Each air-con's response of FastADR varies stochastically
- Along with number of aggregation increase, aggregated responses became converged.



Averaging Effect in FastADR Aggregation Simulations

- FastADR aggregation variation decreases along with the number of FastADR trials.
- Standard Deviation decreases according with approximately $1/\sqrt{N}$ averaging rule.



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OpenADR Related Standardizations in Japan

- JSCA[*1] Standard was published in 2012.
  It introduced several OpenADR use cases.

  [*1]: Japan Structural Consultants Association

- ERAB[*2] Guideline was published in 2017.
  It guides OpenADR payload construction.

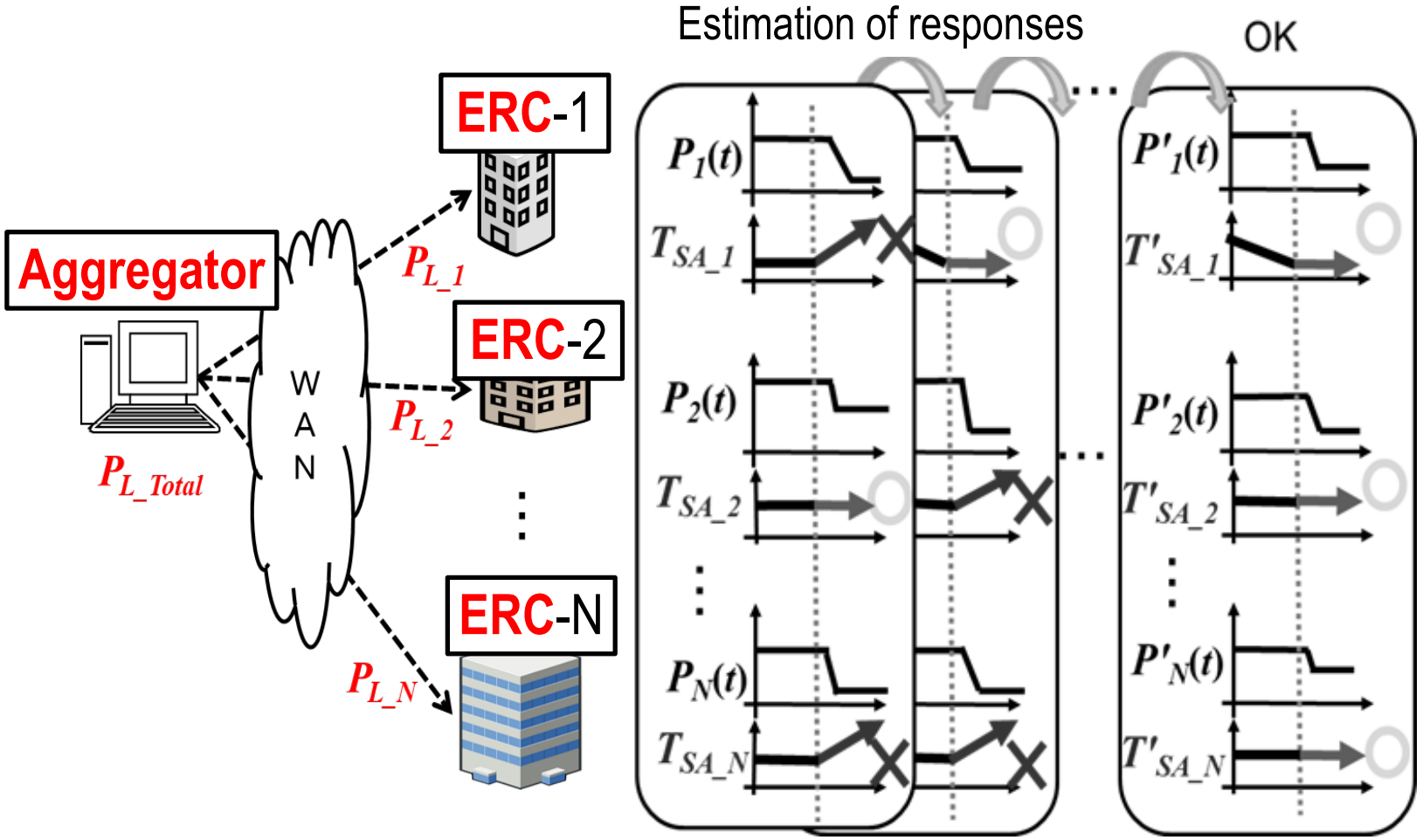
  [*2]: Energy Resource Aggregation Business Study Committee, established by Ministry of Economy, Trade and Industry.

- JEC-TR[*3] series were published in 2018-19.
  The series advises detailed implementation of OpenADR and IEC61850.

  [*3]: Japanese Electro-technical Committee of the Institute of Electrical Engineers in Japan

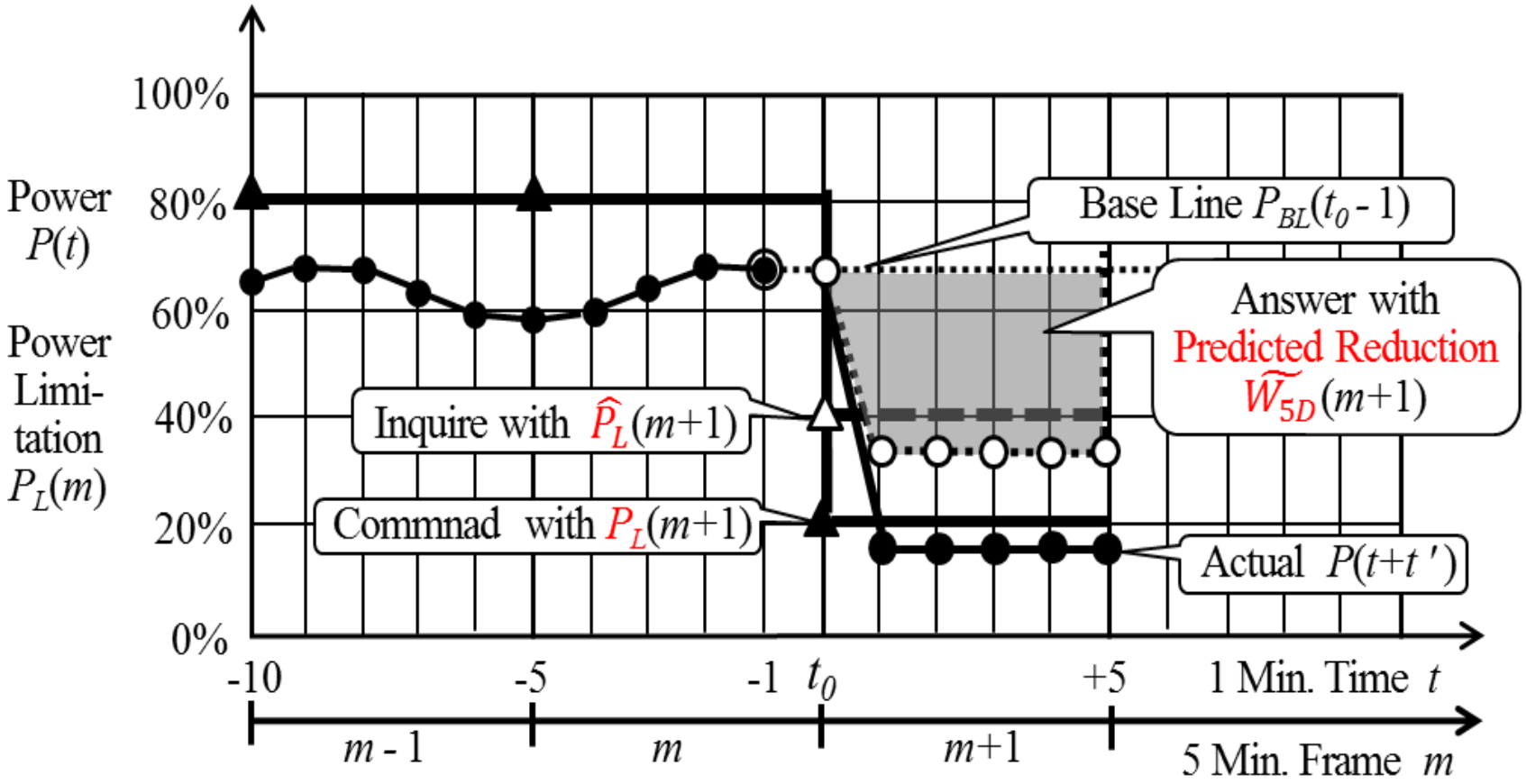
JEC-TR-59004 Main Concern: Allocation of FastADR

- JEC-TR-59004 is specialized for the DR of VRF air-con. aggregation.
- The Aggregator has to estimate the responses, and allocate the power limitation commands P_L to the Energy Resource Controllers (ERCs).



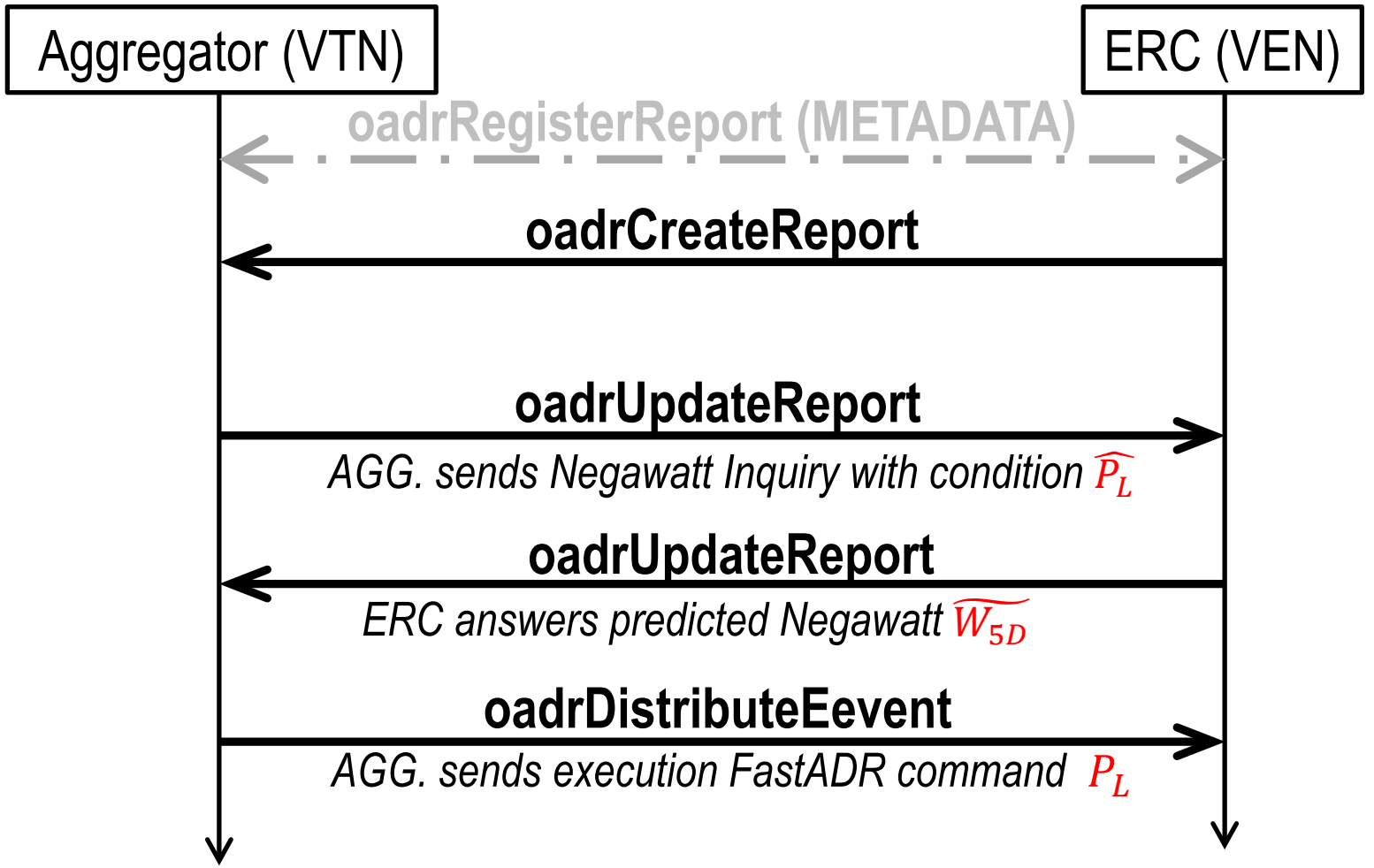
Feature of JEC-TR-59004 : Negawatt Prediction Inquiry

- First, the Aggregator sends the ERC an assumed limitation $\widehat{P_L}$ for the next 5 min.
- Then, the ERC answers the predicted the corresponding negawatt $\widetilde{W_{5D}}$.
- Finally, Aggregator issues an executable power limitation command P_L.



Negawatt Inquiry by using OpenADR (Under consideration)

- Negawatt Inquiry with condition $\widehat{P_L}$ would be implemented by using EiReport service.
- Answer of predicted negawatt $\widetilde{W_{5D}}$ would be implemented by using EiReport service.
- FastADR executable command P_L would be implemented by using EiEvnent service.



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Thank you for your attentions

Simulator for OpenADR Communication of FastADR for Air-conditioners

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https://www1.gifu-u.ac.jp/~ninalab/English/index.html