2013 IEEE PES General Meeting

Vancouver, BC | July 21-25

DISTRIBUTION STATE ESTIMATION
– Wishes and Practical Possibilities –

Goran S. Švenda and Vladimir C. Strezoski

Faculty of Technical Sciences, Novi Sad, Serbia

POTENTIONAL TOPICS

Beckground:
SE Theory & DSE Models

Comparison of transmission and distribution network
⇩
EMS and DMS SE

System modeling for the purpose of DSE (elements, consumption, IT, …)

Possibility of DSE and problems of its application

Theoretical vs Practical DSE

Real-Life DSE Integrated in DMS

Industrial DSE

Experience of application of IDSE in various distribution utilities

Comparison of diferent practical solutions

Comparison of diferent vendors

Comparison of diferent clients

Direction of further development of DSE

… etc.

CONTENTS

Where are we now ?

Industrial Distribution State Estimation

Where are we going ?

I Part

Where are we now ?

WELL-KNOWN

STATEMENTS

FACTS

QUESTIONS

DIFFERENCES BETWEEN SYSTEMS

TRANSMISSION SYSTEMS

- **role:**

  connects sources and consumer areas

- **configuration: mashed**
- **remote control: majority of elements**
- **redundancy of real-time telem. data :**

  > 2.0

MODELS, ALGORYTHMS,

...

≠

DISTRIBUTION SYSTEMS

- **role:**

  supplies group of consumers

- **configuration: radial**
- **remote control: modest**
- **redundancy of real-time tel. data:**

  0.2 ÷ 0.3

MODELS, ALGORYTHMS,

...

STATE ESTIM. for EMS and DMS

EMS SE

- well known, modeled in ’70s.
- practically realized 20 years ago
- provided estimation of quality for:
  - network state
  - wrong measurements
  - network topology
  - network parameters

DMS SE

- the idea in ’90s
- practical realization in progress
- provided estimation for:
  - measurements
  - topology ???

EMS SE ≠ DMS SE

DISTRIBUTION STATE ESTIMATION

MODELS, ALGORITHMS, ... $\neq$ **MODELS, ALGORITHMS, ...**

EMS SE $\neq$ **DMS SE**

PROBLEMS

Mathematical Model !?

Implementation in Field !?

STATE ESTIMATION MODELS

Approches :

- EMS SE adjusted to be applied in DN
- Highly specialized SE for DN
- SE of both transmission and DN
- Based on heuristic rules
- Based on probabilistic rules
- State vector consists of buses voltages
- State vector is represented by polar and by rectangular coordinates
- Measurements of P, Q, I and V phasors are synchronized and processed simultaneously
- Measurements of V are disregarded or processed individually … etc.

Techniques / Procedures :

- Weighted least squares (WLS)
- Decomposition of WLS problem into a series of separate WLS problems
- Determination of sensitivity zones
- Newton method
- LaGrange Relaxation
- Neural network
- Fuzzy logic
- Artificial Intelligence
- ... etc.

STATE ESTIMATION MODELS

- **Theoretical papers, applicable for:**
  - **Small test networks, without meshes, services trs, CB, VR, …**
  - **Networks with one voltage level and small number of different consumer types**
  - **Short time intervals …**
- **Rely on unacceptably large number of various data:**
  - **P, Q, V, I, …(modules and phasors)**
  - **SCADA, GPS, PMU, SMI, …**
- **There is a small number of papers:**
  - **About SE integrated in DMS, applied in real-life**
  - **With results of SE application on a real DN**

REQS FOR PRACTICAL REALIZATION

- **DSE has to be applied in any distribution utility :**
  - **completely, partially covered by SCADA systems**
  - **very huge, bi-level, weakly-mashed schemes**
  - **(un)balance sistem with (un)symmetric state**
- **DSE must take into account:**
  - **all measurements and statuses**
  - **local logic, automation, cascade automated CB, VR, …**
  - **motors, DG, IPP, Energy Storage, EV Charging, …**
  - **load-to-voltage dependences …**
- **Real-Time DSE:**
  - **enough fast and robust**
  - **reliable 24 / 7 / 365**
  - **…**

COMPROMISE

Complex methods proposed in the literature

Characteristics and Possibilities of distribution utilities

C O M P R O M I S E !!!

I part - FACTS

Standard model of DSE and a procedure for its solution have not been determined yet.

Integration into DMS and SG concept are negligible.

Practical verification is negligible.

Why ?

I part - QUESTIONS

Why has industrial-grade DSE product not been established yet ?

Are the developed models practically applicable?

Are DPU ready for their application ?

What do DPU want, and what is offered to them ?

What is Industrial DSE ???

II Part

Industrial Distribution State Estimation

DSE – BASIC

STRUCTURE

PROBLEMS

IMPLEMENTATION

DISTRIBUTION STATE ESTIMATION

DSE formulation :

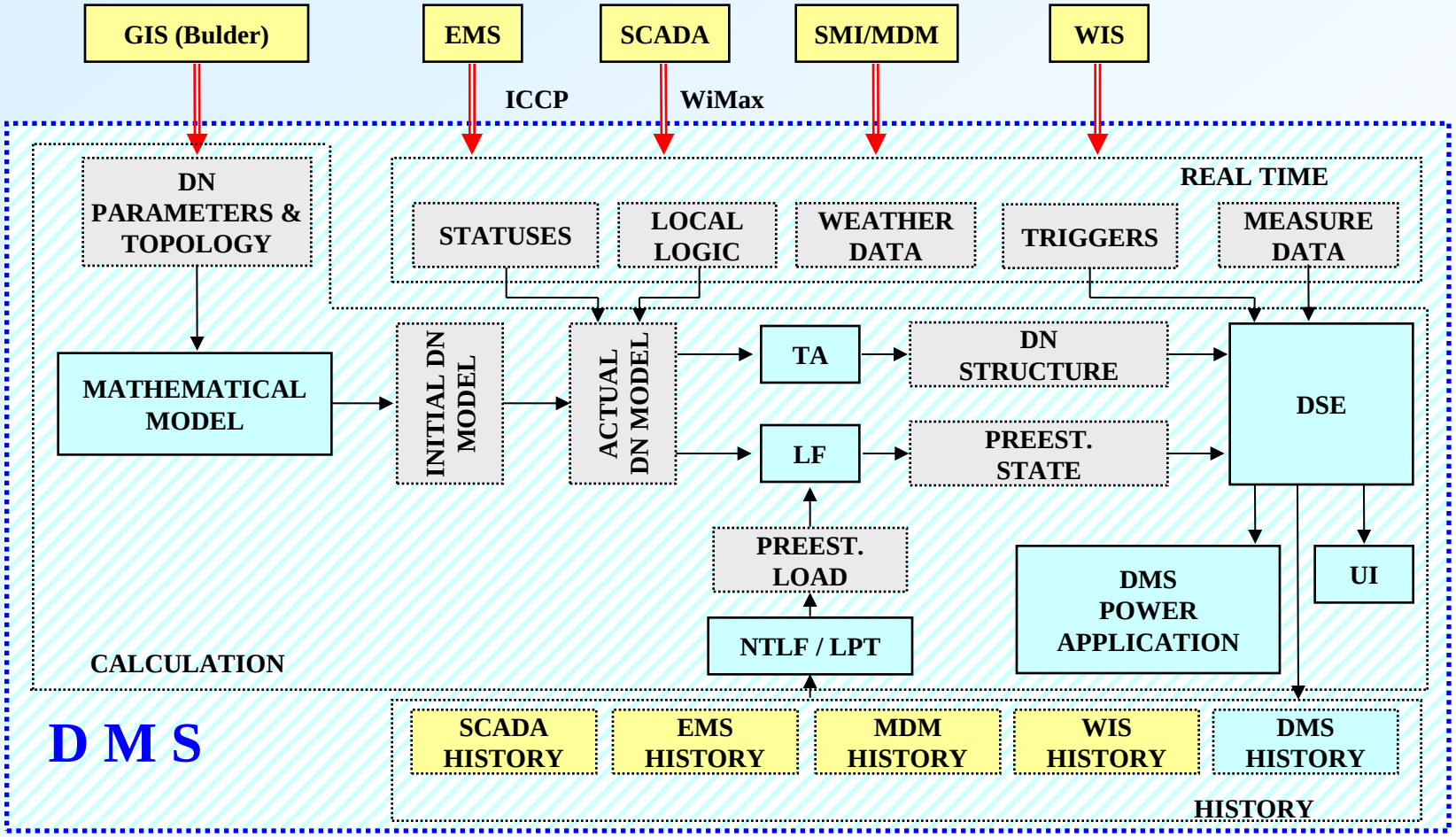
Determine the state of DN which is optimally tuned with:

- **original measurements and topology**
- **DLPs of shunts**
- **ULTCTs operation**
- **values estimated in supply network**
- **resources for active and reactive powers control operation**

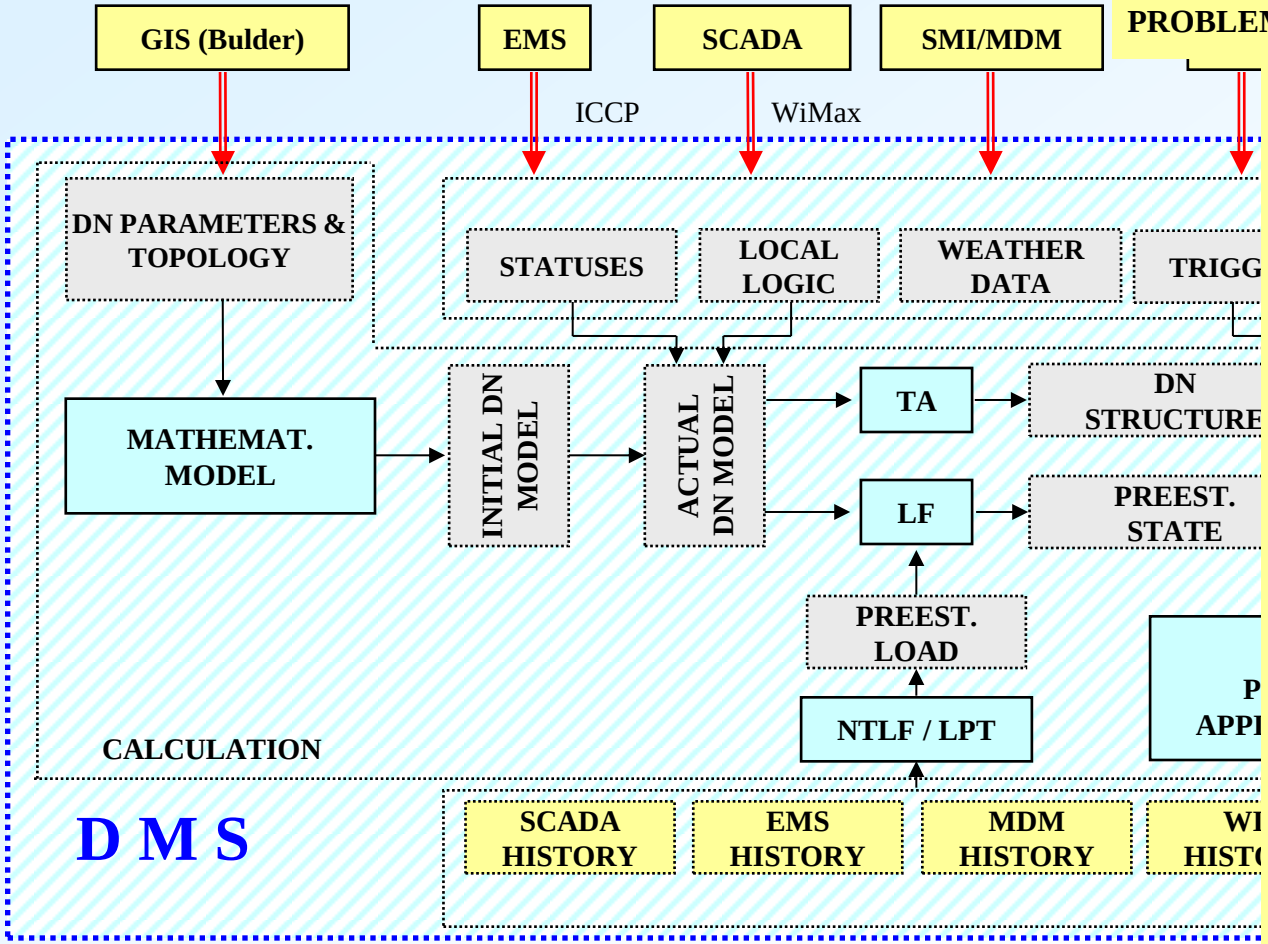
Based on :

- **Sensitivity zones (defined by measurements locations)**
- **Topology and Incidence matrices**
- **Fictitious measurements (Preestimation)**
- **Eqs of balance of P and Q of zones**
- **Classic Constrained Optimization Problem & Load Flow**

INDUSTRIAL DSE



INDUSTRIAL DSE



PROBLEMS:

- DATA
- MATH. MODEL
- ARHITECTURE
- INTEGRATIONS
- SERVERS
- SERVICES
- ENVIROMENT
- TRIGGERING
- COMINICATIONS
- LOCAL LOGIC
- CLOSED LOOP
- SINHRONIZATION:
  - DIF. VENDORS
  - DIF. CONTROL DEVICES
  - DIF. COMMAND EXECUT.
  - DIF. DATA COLLECTION
- TIME & MONEY CONSUMING
- MAINTENANCE
- NEW RESOURCES
- VERIFICATION

III Part

Where are we going … ?

SMART GRID ERA

NEW CHALLENGE FOR DN

…

…

WHERE ARE WE (GOING) ?

- **We are in Smart Grid era :**
  - **DG, IPP, SMI, Energy Storage Systems, …**
  - **The large-scale deployment of Smart Meters …**
  - **From being in an under-determined to over-derermined state**
  - **DN is being developed from totally passive to active DN**
- **Where are we going :**
  - **Direct Load Control**
  - **Full automatization ⇨ DMS in Closed Loop**
  - **DMS self-learning**
  - **Model self-correction**
  - **Smart City (Smart House, Electic car, …) …**

INSTEAD OF CONCLUSION

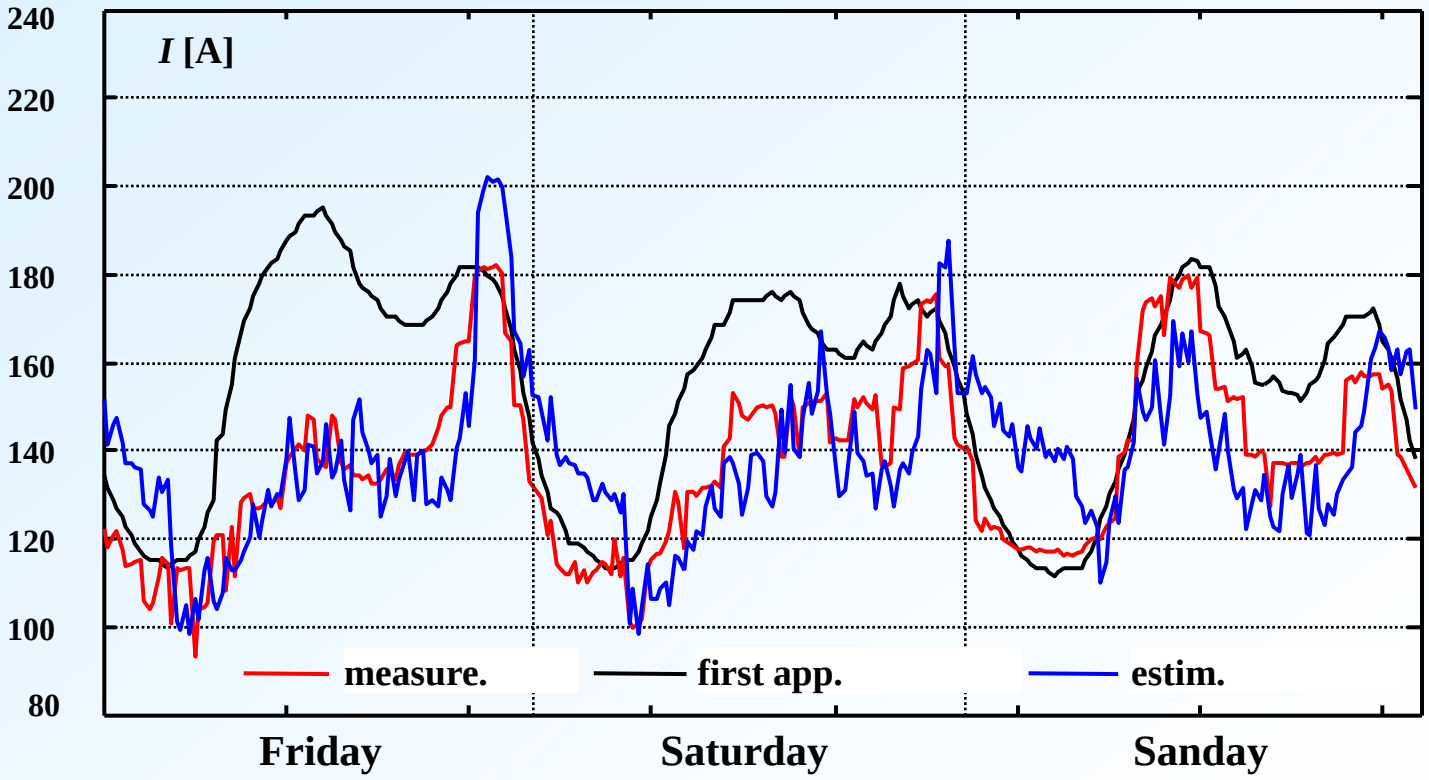
What have we learned by imeplementation of SE in the field ?

- **Mathematical model is just one of problems (a smaller one)**
- **DSE needs Investments in distribution (metering infrastructure)**
- **Realization of IDSE is very expensive and time consuming process**
- **IDSE cannot be realized on one computer (server)**
- **IDSE cannot be done by one man or small group of engineers (this work includes participation of many well organized various experts)**

BUT

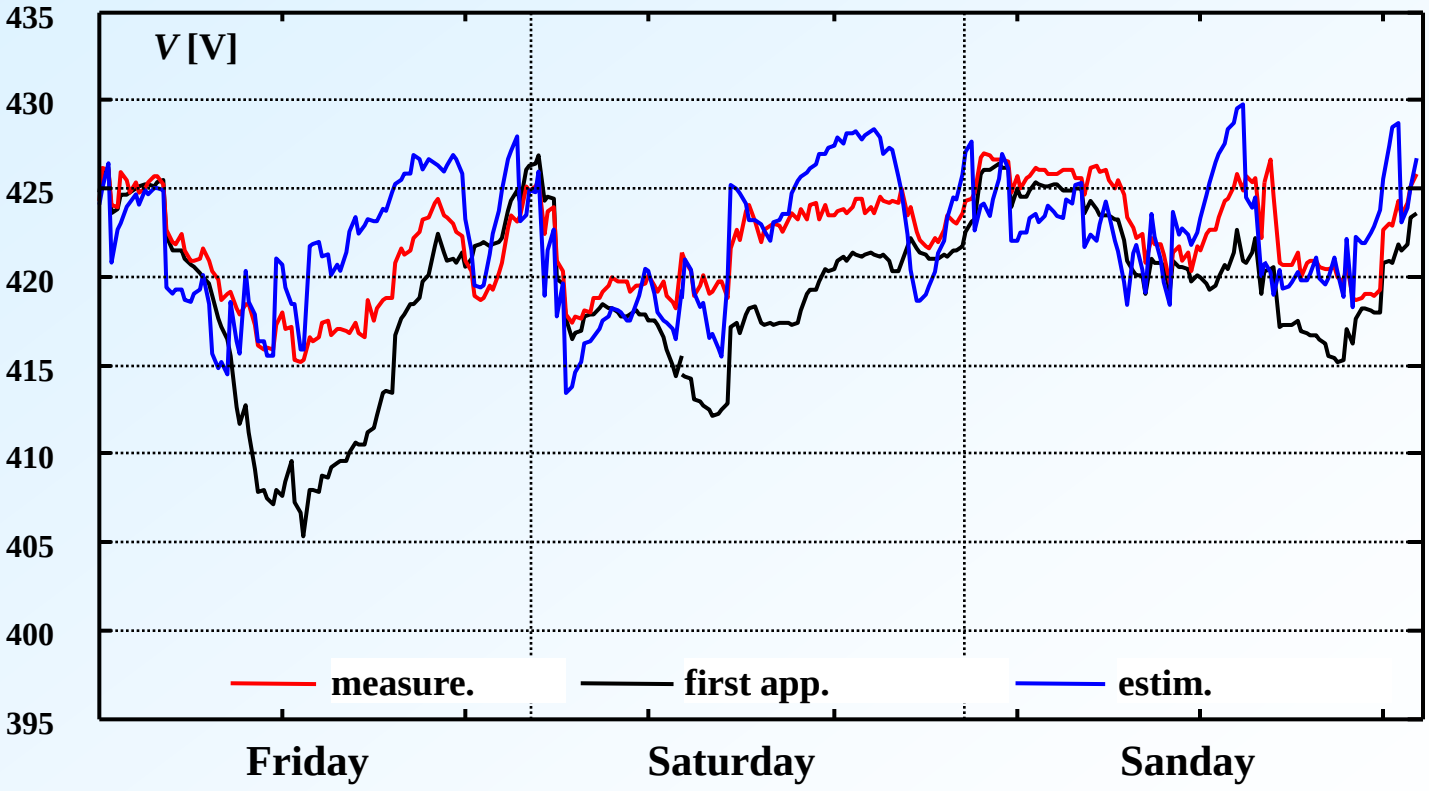
IDSE can be realized in Real-Life !

INDUSTRIAL DSE – RESULTS



Distribution SS current on 0.4 kV side

INDUSTRIAL DSE – RESULTS



Distribution SS voltage on 0.4 kV

Thank you …

Goran S. Švenda

svenda@uns.ac.rs