WAMS Analytics for Electrical Transmission Systems

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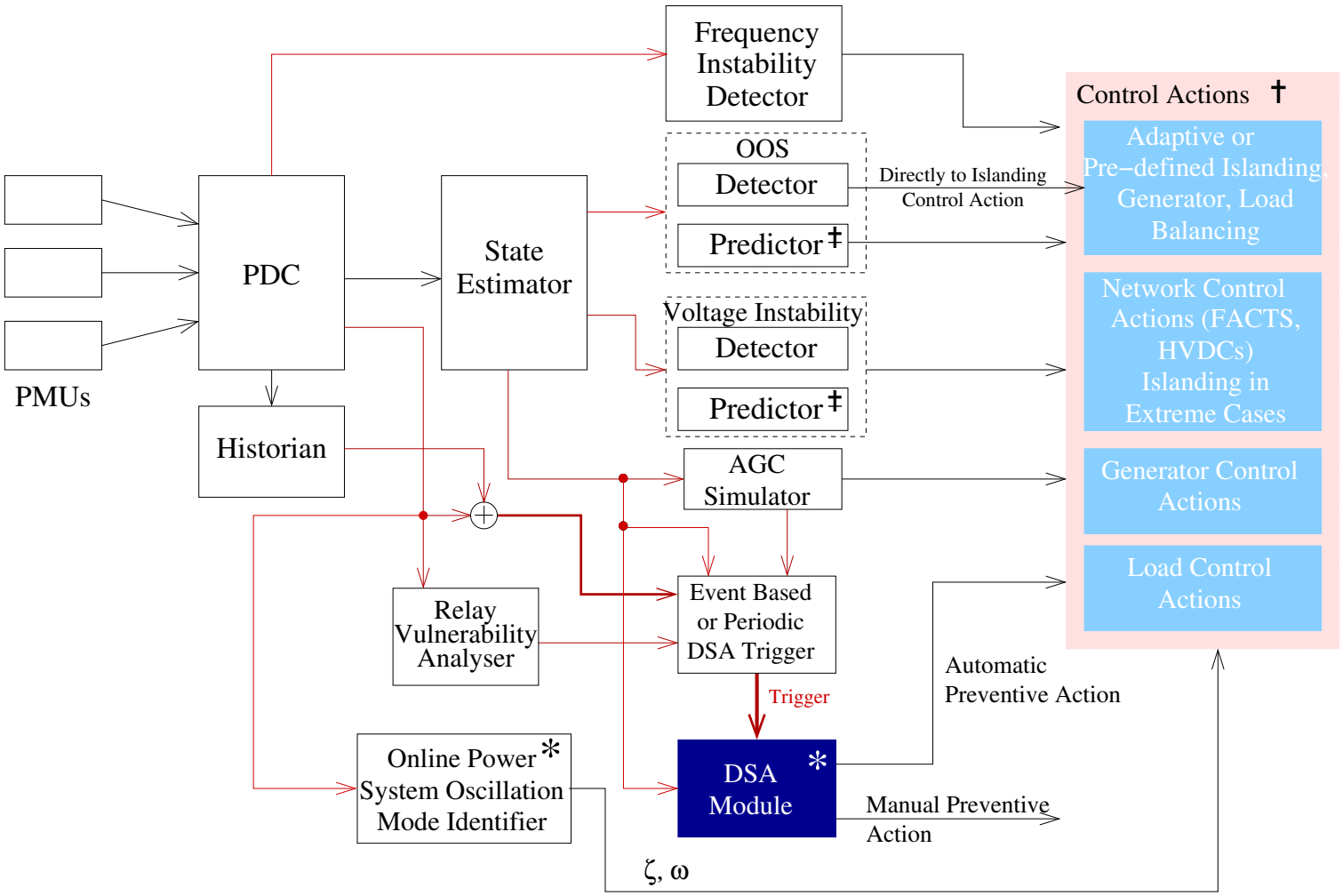
Agenda

- Synchrophasor analytics architecture
- List of WAMS analytics to be developed
- Development Plan
- Test Environment

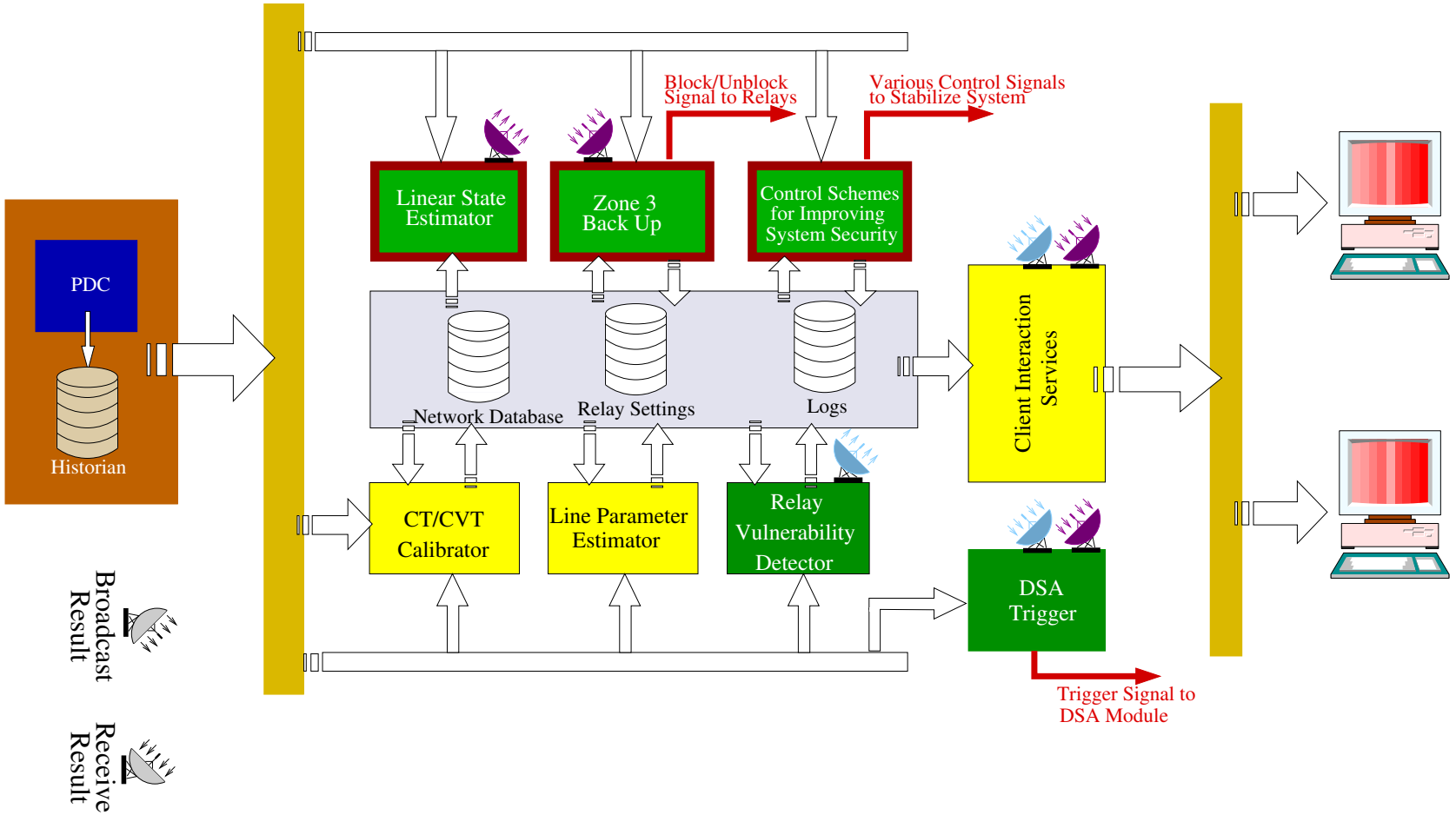
PMU analytics

- Line Parameter Estimation
- Online Vulnerability analysis
- Linear State Estimation
- CT/CVT Calibration
- Supervised Zone-3 Distance Protection
- Control Schemes for Improving System Security

Control Schemes to improve System Security



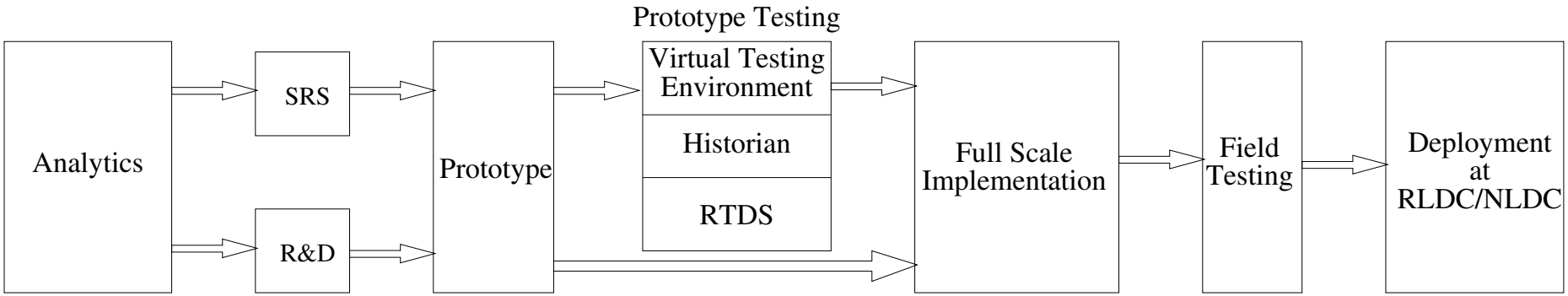
Overall PMU Analytics interlinkage



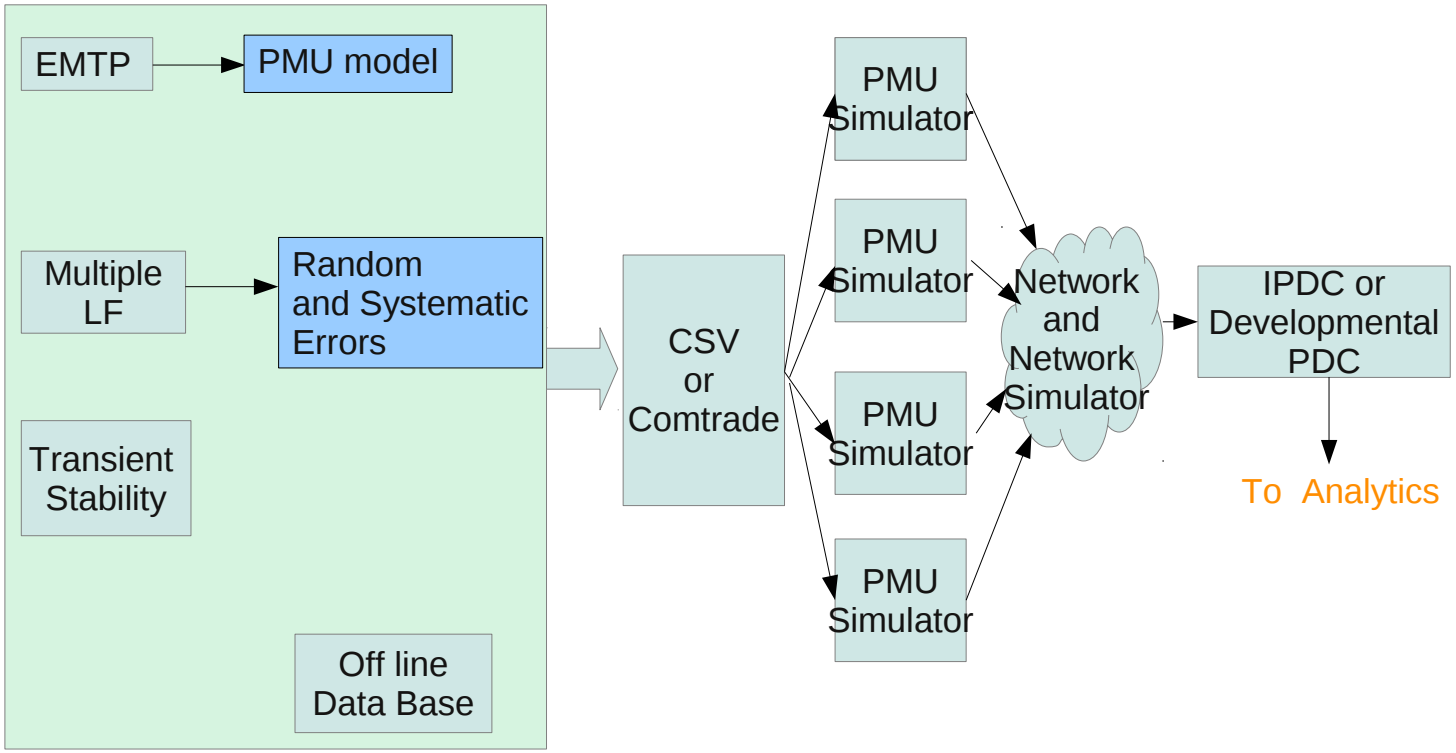
Analytics & User Interface requirement

Module	Mode	UI Requirement
Line Parameter Estimation	Offline	Nominal
Vulnerability Analysis of Distance Relays	Online	Visualize swing and relay setting on R-X plane
Linear State Estimator	Real Time	1. Substation drawing editing tool along with CB status display. List of physical and electrical buses. 2. SLD visualization cum editing tool. 3. Visualization of observable network. 4. Visualization of state estimation results like voltages angles, line flows (MW, MVAR), phasor currents etc.
Supervised operation of Zone-3 relays	Real Time	Customized plot of residuals or differential currents
CT/CVT calibration	Offline	Nominal
Control schemes for improving system security	Real Time	Low

Analytics Development Process flow diagram



Virtual Test Environment Block Diagram



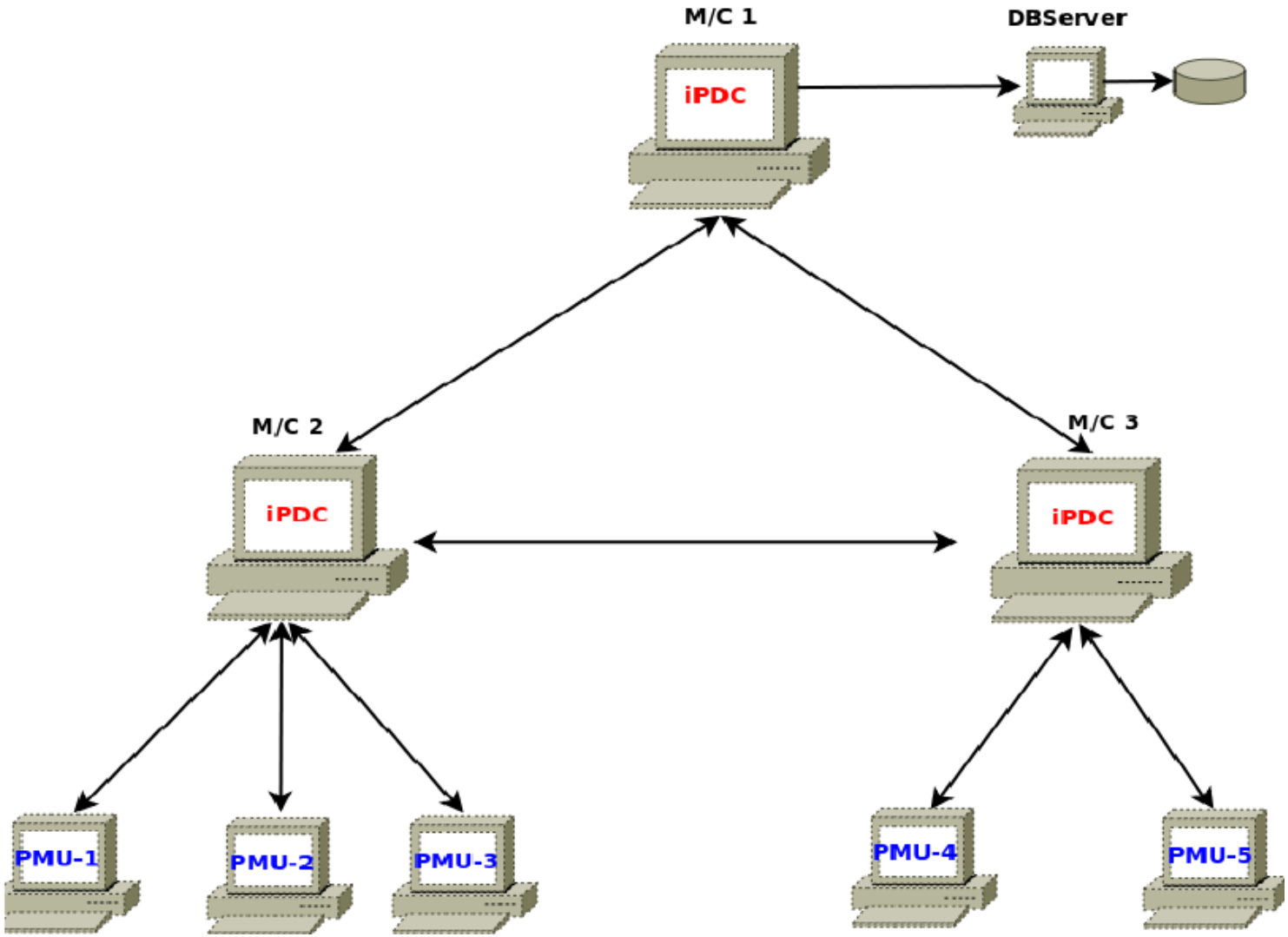
iPDC Suite

- iPDC - IIT Bombay PDC
- iPDC suite is a combination of three separate components
  - PMU Simulator - To simulate a PMU
  - iPDC - An actual PDC
  - DBserver - Database server to store the phasor measurement data
- Built on Open Source platform and released under GPL
- Being used in Academcis and Industry

iPDC Suite

- Compliant with IEEE C37.118-2005 Standards - Work going on to make it compliant with 2011 version
- Facility for local and remote archival of phasor measurement data
- Support for both TCP and UDP communication
- Diagnostic faclitity to check network latency
- GUI to setup PMU Simulator and iPDC

WAMS testing through iPDC Suite



Common Facilities for Development of Analytics

1. Virtual Test Environment / Simulated Environment to achieve the following objectives
   - 1.1 Collect the data representing NEW Grid
   - 1.2 Define/Configure Scenarios
   - 1.3 Generate measurements through Simulations using LFA, TSA, EMTP etc.
   - 1.4 Play the above results through PMU simulator
   - 1.5 Pass the frames generated to PGCIL provided PDC or iPDC

Common Facilities for Development of Analytics

2. Network Data Repository
   - 2.1 A common data repository containing actual PMU data (historical) that captures various operating conditions and abnormalities
   - 2.2 The data goes through a validation check.
3. PDC & Historian Interface
   - 3.1 An Interface module will be developed that will be able to communicate both with either the Historian or the PDC
   - 3.2 Any future changes of PDC interface protocol will be handled by this module
   - 3.3 The historian interface will be based on COMTRADE/ CSV format

Software Development stages (1)

- Systems requirement studies & documentation
  - All technical,functional & non-functional aspects to be captured
  - All fine points to be addressed
  - SRS document to be the guiding document for each analytic module
- User Interface Conceptualization
  - To produce intuitive UI for the various modules
  - Approach is to keep simple 'look and feel'
  - Seek active participation from PowerGrid Engineers during this stage
- Research & Development
  - Detailed modeling and study of each analytics
  - Freezing of algorithms
  - Rigorous testing and validation for correctness of the approaches

Software Development stages (2)

- Algorithm PoC
  - PoC will be done through rapid development through Matlab, Octave, Python & C/C++ code
  - Simulation of real-world network to be done using EMTP, LFA & TSA. If required, RTDS simulation will also be considered
- Software Implementation/Integration
  - This stage comprises of integration of various individual modules/subsystems with the live streaming data through Master PDC
  - Addressing all the issues pertaining to smooth functioning of the entire system

Software Development stages (3)

- Field Testing
  - This stage will comprise of running & verifying coverage of all real world scenarios
  - Testing on a 10 PMU test system after engine implementation. Following aspects will be tested
    - Latency
    - Computation time
    - Correctness. Results obtained will be validated with offline computation
    - Robustness. Analytics should work without disruption and handle communication failure
  - Successful implementation & testing at all RLDC and NLDC

Thank You