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# POSSIT

**POwer System Security using Intelligent Technologies**

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## Background

In recent decades power systems have evolved into extremely complex, high-order systems which include wide ranges of controls with diverse time frames of operation and varying degrees of intelligence and automation. Power systems can span entire continents and indeed may represent the most complex control systems in existence. They must be designed and operated in such a way as to ensure that all system variables, (such as customer voltages, system frequency, and power flows on transmission lines) remain within acceptable ranges and are controllable during normal conditions and following any disturbances that may occur. This is the essence of power system security.

An insecure system is prone to failures that may have wide ranging impacts including customer power interruptions, equipment damage, huge financial losses, or even loss of life. The ability to ensure security can provide enormous technical and economic benefits.

Security assessment and system control is currently achieved through a mix of technologies including a huge number of local automatic controls (such as generator excitation controls) and some centralised security assessment which provide human operators with information from which they determine and invoke manual control actions. The human link provides intelligence and control in this extremely complex system.

In the new deregulated environment, the system conditions are difficult to forecast (since market factors are the driving force and the variations in possible power transactions are virtually endless) and, therefore, power system security is difficult to predict far in advance. *On-line security assessment* in which a snapshot of the system is captured and analytical engines are used to assess security in near-real-time is now becoming necessary and tools have been developed for this purpose. However, it is still difficult to fully assess the system in real-time using use these "conventional analysis" techniques due to the size of the system, and enormous number of possible system conditions and contingencies that may occur.

The solution is to develop new technologies using artificial intelligence and intelligent control systems which can have the benefits of analytical analysis as well as exhibit human-like adaptability and decision making capabilities to assist in *evaluating system security* and *providing control decisions*.

## The Project and the Project Team

The POSSIT Project is a project sponsored by PRECARN (A Canadian research organization), BC Hydro, Hydro Quebec, and the Alberta Research Council. The main project participants include Powertech Labs Inc. (subsidiary of BC Hydro), IREQ (research wing of Hydro Quebec), the Alberta Research Council, and the University of British Columbia.

## The Technology

The POSSIT project is developing a Intelligent System (IS) which can be used on-line (in control centers) to quickly assess the transient stability limits of large complex power systems. The POSSIT technology is a software environment which can utilize available dynamic security assessment (DSA) engines (time domain simulation tools) and IS tools (such as data mining) to provide security limits – the basic structure is shown in the figure below.

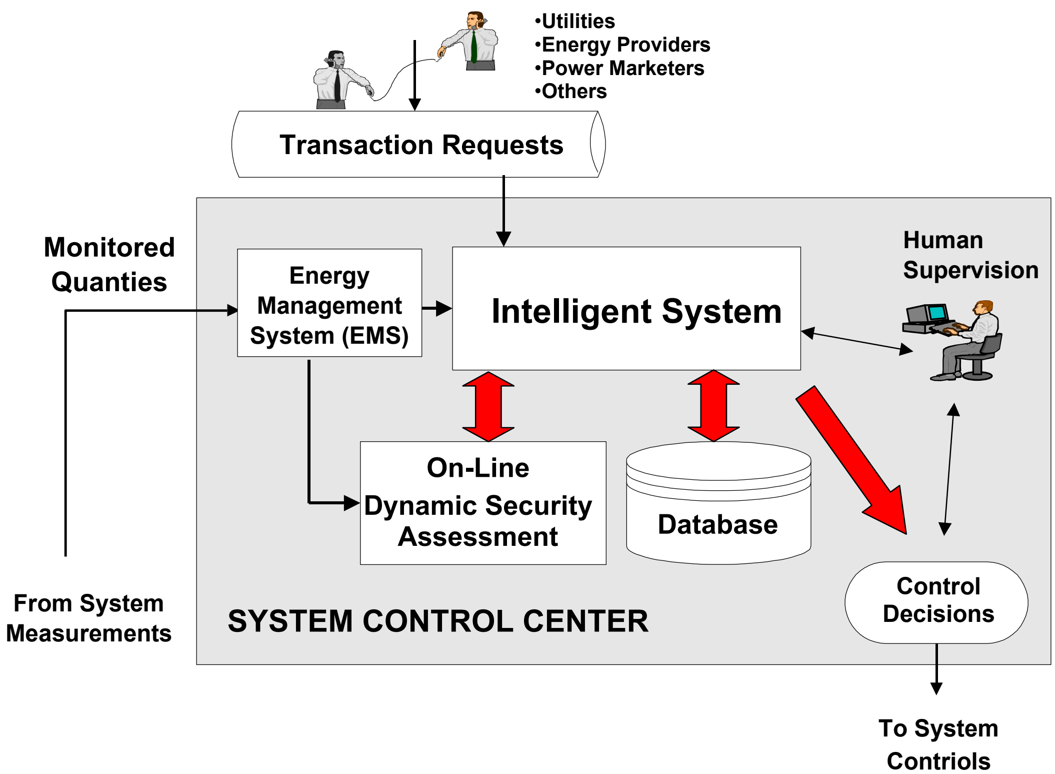


*Figure 1 : POSSIT Project Architecture*

The software product is a comprehensive program that includes tools for,

- Automatically creating training sets for the IS system
- Database analysis and data cleaning
- Running of the IS engine to automatically find the system security limits.

## The Benefits

The POSSIT technology allows real-time assessment of stability limits and takes into account a greater range of system conditions and contingencies than conventional methods. As a result, the technology is expected to,

- Allow operation of power system closer to their actual limits thereby increasing facility usage and increasing potential revenues
- Increase system security through better knowledge of the actual stability limits, thereby reducing the number of disturbances
- Eliminate the need for extensive and costly off-line predictive analyses

- Provide security assessment which addresses the uncertainties of the open market environment

## Design Details

The POSSIT project is developing a software environment that can use intelligent systems together with existing dynamic security assessment software to provide very fast on-line assessment of power system transient stability limits. The basic approach is described below.

Decision Trees (and regression trees) are the primary intelligent system technology used in the POSSIT project. To develop the decision trees, a very large Intelligent System (IS)Data Base (DB) is created which consists of a large number of objects, each representing a power system pre-contingency state (effectively, each object is a set of key attributes from a powerflow solution) together with the results (stable or unstable) of a transient stability simulation for a contingency. The simulation is conducted using a full time domain engine. For the POSSIT project Powertech's DSA PowerTools$^{TM}$ and IREQ's ST600-based tools are used for time-domain simulation.

The large database can be interrogated and reduced to eliminate redundant data using special clustering and correlation methods. The reduced database is then used as input to tools that can build decision trees (DT). The POSSIT design is intended to be general such that different decision tree building tools could be used. Initially two DT tools are being used, one commercial tool and one public domain tool (WEKA).

Once the DTs have been built, the system is ready to run. The snapshot of the system condition will be fed to several paths in order to establish the system security,

Path 1 : Conventional dynamic security assessment software (time domain simulation)
Path 2 : Look-up of similar system conditions from conventional look-up tables
Path 3: Look-up of similar system condition from the IS database using "nearest neighbor" techniques.
Path 4: Dropping the object on the decision trees.

Path 1 is the slowest, but most accurate (conventional). Path 2 is included as it is an existing method. Path 3 and 4 are the main IS approaches and will return the stability condition. By looking through this function, the stability limits can be found.

### Main Components

The following describes the main components in the POSSIT system.

***Data Builder –** (See Figure )*

This module includes a ***Scenario Generator*** which allows the user to define a set of scenarios which will be used to create the large IS database which will in turn be used to build the decision trees. The Case Generator produces a control file that then runs the full time domain simulations and determines the stability condition for all the defined scenarios. Prior to running the time-domain simulations, the ***Engineered Attribute Selector*** may be used to specify which output quantities (such as bus voltages or generator output powers) should be eliminated or retained. This assists in reducing the output database size.
The output of the Data Builder is a large database of objects (several thousand) each consisting of a number of attributes (several hundred items such as voltages and flows) and a target attribute

indicating the stability condition for that specific object.

***Intelligent System (IS) Builder*** *(See Figure 2)*

This module includes a ***DB Interrogator*** which allows the user to perform statistical analysis on the DB and select or reject objects or attributes. This module also connects to the DT building software to build the trees. The trees are developed from the large DB and are outputted as program executables which can be run later.

***On-Line Intelligent System Controller –*** *(See Figure 3)*

This module connects to the live EMS system and takes the system condition from the state-estimator and creates an object which can be dropped on the decision trees which have been created. This module also connects to the DSA analytical engines (time-domain simulations) and KNN (nearest

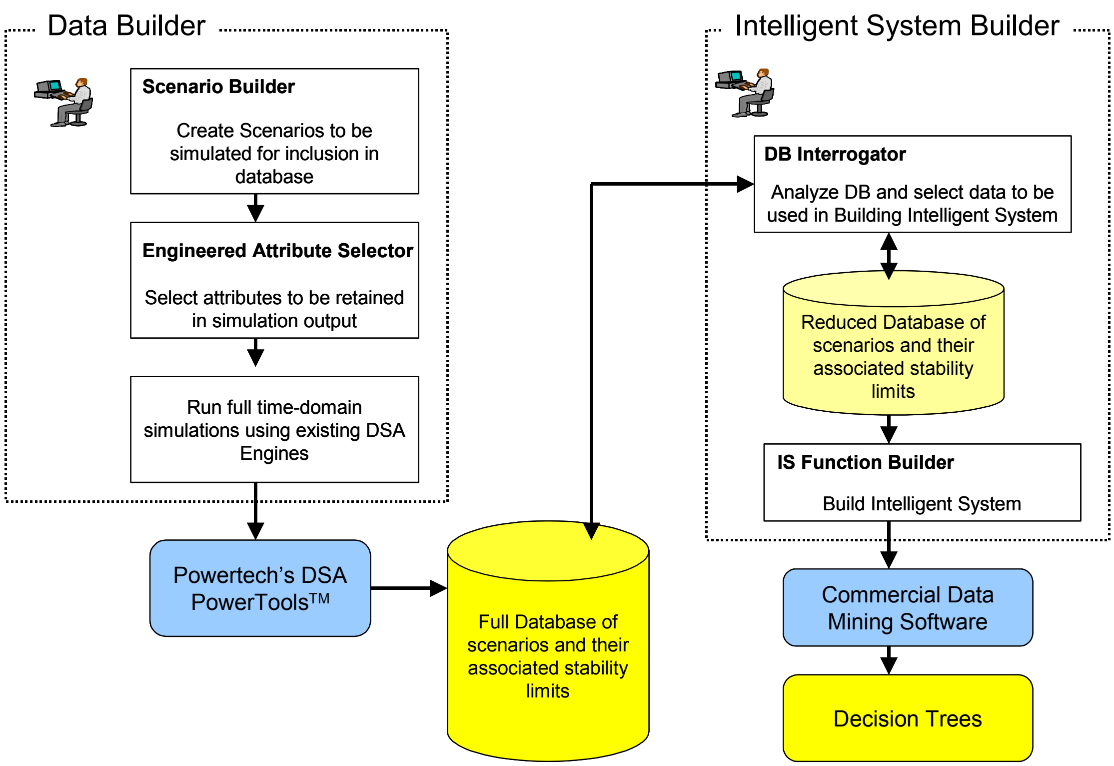


*Figure 2: Setting up Intelligent System (IS) Using the Data Builder and IS Builder*

neighbor) software, and conventional look-up tables (if provided). The output of the IS controller is the system stability condition (Stable or unstable) or the actual stability limit if the limit loop is used.

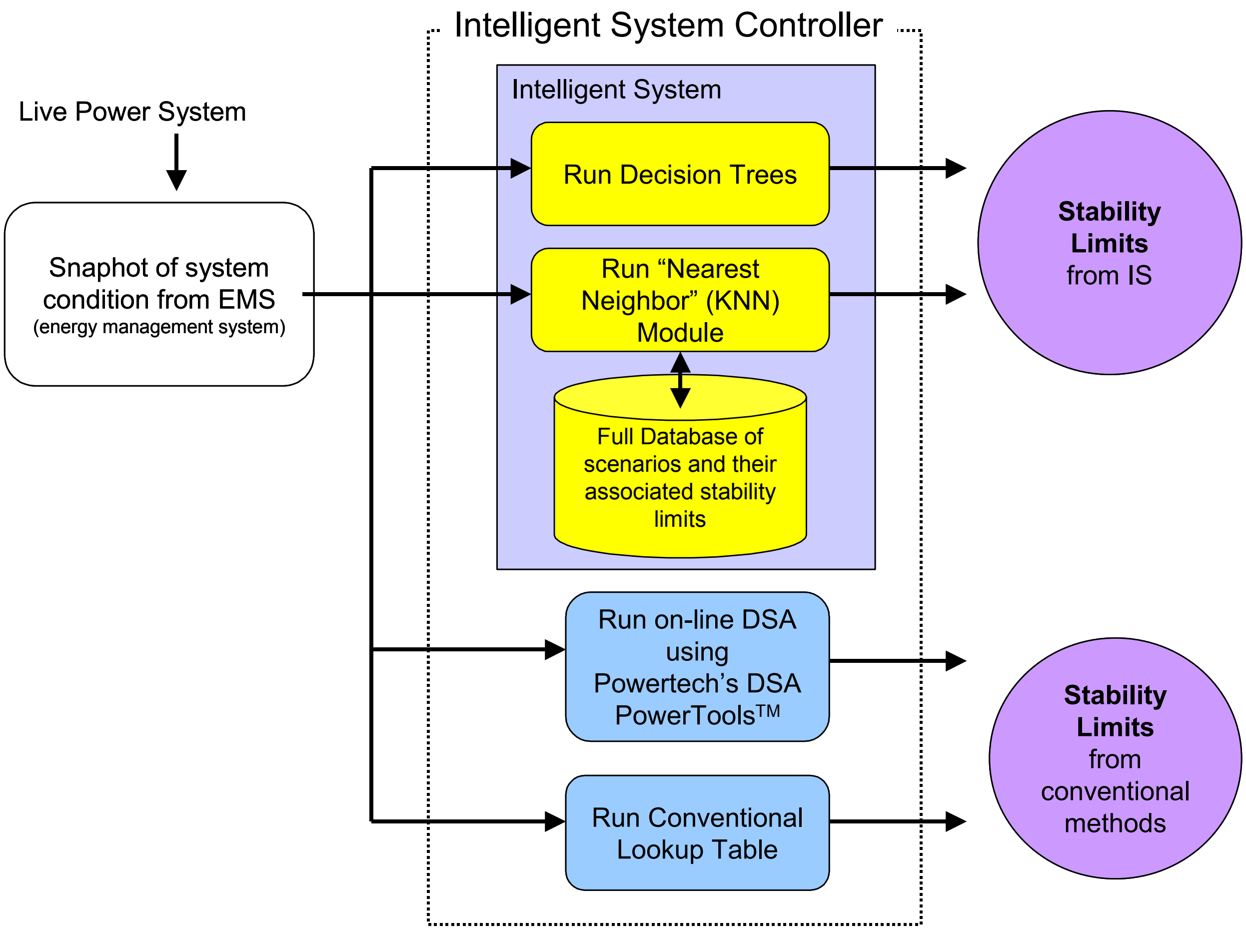


*Figure 3: Running the Intelligent System On-Line*

## For More Information

For more information on the POSSIT Project or On-Line Dynamic Security Assessment, contact,

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