INTEGRATED STRUCTURE OF DECISION SUPPORT SYSTEM FOR PREDICTIVE MAINTENANCE OF ENGINEERING SYSTEMS

D. Borissova and I. Mustakerov

AUTOMATICS AND INFORMATICS'2013, 3-7 October 2013, Sofia, Bulgaria

Introduction

- Nowadays, production assets are under constant pressure for reducing operating costs, enhancing reliability of the equipments, and improving the quality of the product.
- Intelligent fault diagnosis and failure prognosis is a cutting-edge direction involving interdisciplinary methods.
- It requires understanding of the physics of failure mechanisms for condition-based maintenance in materials and structures and also presents strategies to detect faults or incipient failures.
- The goal is to provide a integrated structure of decision support system (DSS) for engineering predictive maintenance helping to take intelligent decisions.

Introduction

- Condition-based maintenance (CBM) is a decision-making strategy to enable real-time diagnosis of impending failures and prognosis of future equipment health, where the decision to perform maintenance is reached by observing the "condition" of the system and its components.
- CBM method is used to reduce the uncertainty of maintenance activities, and is carried out according to the need indicated by the equipment condition. The existence of indicative prognostic parameters can be detected and used to quantify possible failure of equipment before it actually occurs. In maintenance, common problems of equipment are aging and deterioration.

Introduction

- The CBM is conceived to detect the onset of a failure, avoiding critical damages of high cost components before they might happen, thus reducing overall maintenance costs.
- Possible faults are detected by monitoring representative parameters by signal analysis techniques and comparing signals during normal and abnormal conditions.
- Also, the methods of case-based reasoning can be applied in units of analysis of the problem situation, search for solutions, learning, adaptation and modification, modeling and forecasting.
- The most effective predictive maintenance programs trend to looking for signs of early failure, allowing the equipment to be repaired at minimal cost and down time.

Problem Description

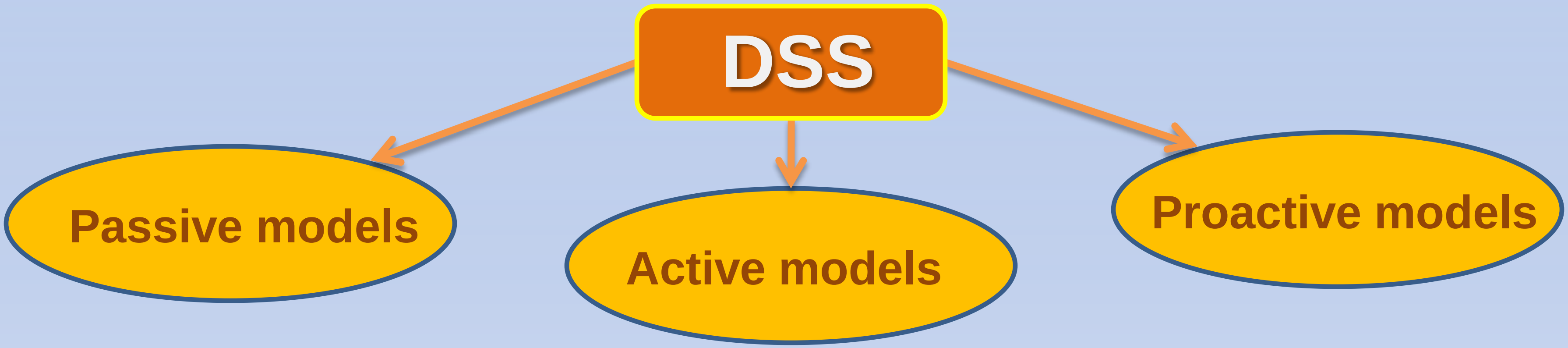
- In order to best utilize trend analysis, data must be available on a regular basis. Obviously, the more frequently the sampling is performed the more accurate the analysis becomes. Diagnostic reports from the DSS on the condition of the machinery assist maintenance personnel in making critical decisions regarding equipment health conditions.
- DSS as computer-based information system supports business or organizational decision-making activities. From maintenance point of view, a properly designed DSS should integrate decision making process with the capabilities of expert system to make a decision in a specific problem setting.

Problem Description

- Because decision-making is based on many different considerations, DSS belong to a multidisciplinary environment, including among others database research, artificial intelligence, human-computer interaction, simulation methods, and software engineering.
- Combining the capabilities of DSS with advantages of expert system (works from a much larger set of modeling rules, uses concepts from artificial intelligence to process and store the knowledge base and scans base to suggest a final decision through inference) an integrated framework of DSS for metallurgical engineering predictive maintenance is proposed.

Generalized Concept of DSS

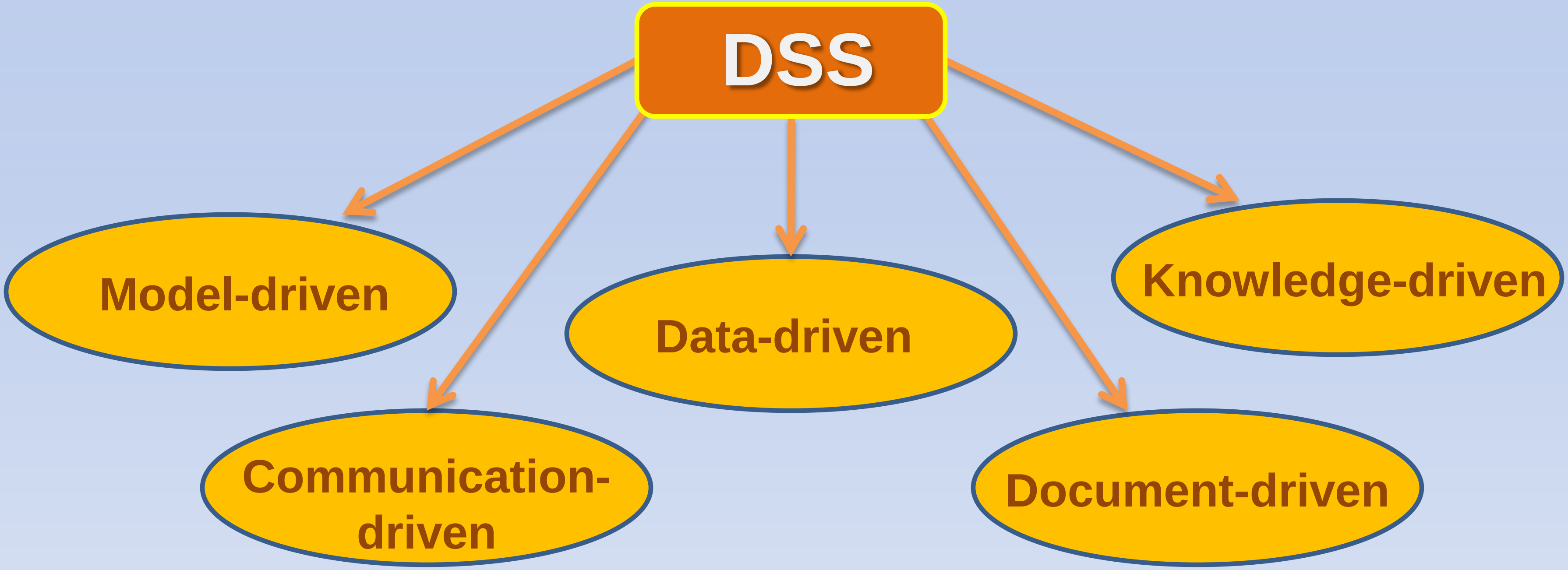
- Concerning the relationship between users and applications, DSS can be divided into three categories – passive, active and proactive DSS:



- The **passive models of DSS** only collect data and organize it effectively and do not provide specific solutions, i.e. they show the collected data.
- **Active DSS** process data and clearly show solutions based on that data.
- **Proactive DSS**, known as ubiquitous computing technology-based DSS, contains decision making and context aware functionalities.

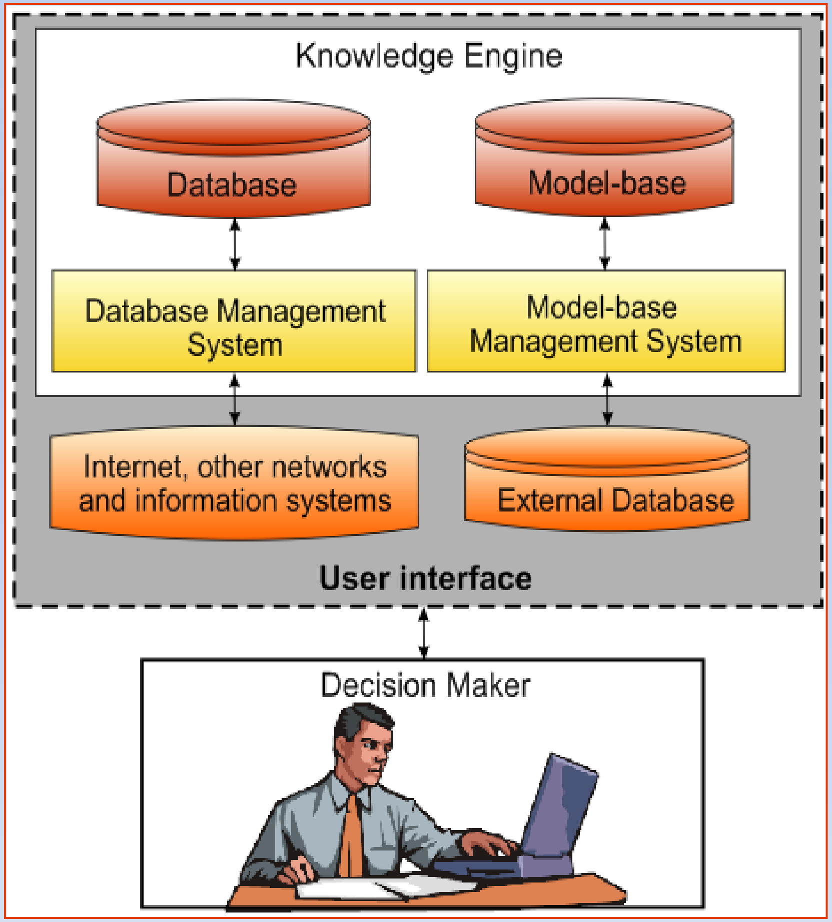
Generalized Concept of DSS

- While the above DSS models take into account the interaction with the user, another popular DSS model consider the way of support



Generalized Model of DSS

- DSS are often an agglomeration of different techniques and methods that aim at fulfilling a function to support the decision maker.
- DSS structure consists in many modules and sub-modules depending on the flow of collecting and processing data.
- Three fundamental components of DSS are database management system, model-base management system and dialog generation and management system.

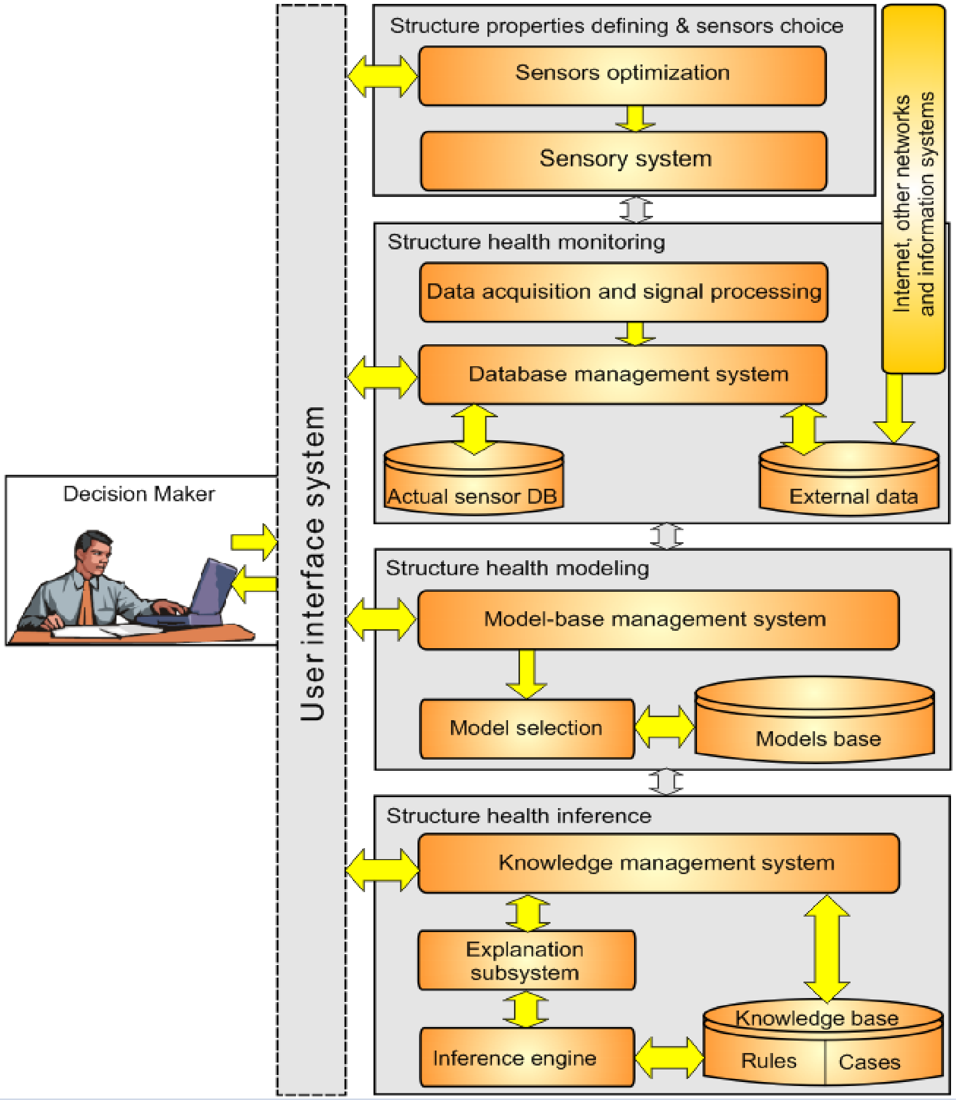


Integrated structure of DSS for predictive maintenance

- The specifics of the predictive maintenance require usage of some monitoring system for engineering critical structural sections. This ensures that appropriate sensors for the requirements of monitoring will be selected and optimally located in such a way that sufficient information can be gathered.
- Typical predictive maintenance includes methods for data acquiring and information fusion combined with signal processing. In the current paper, knowledge management subsystem is proposed as a module in the DSS. It stores and manages knowledge from prior data, human expertise, examples (cases) for the goal of machine learning and case-based reasoning.

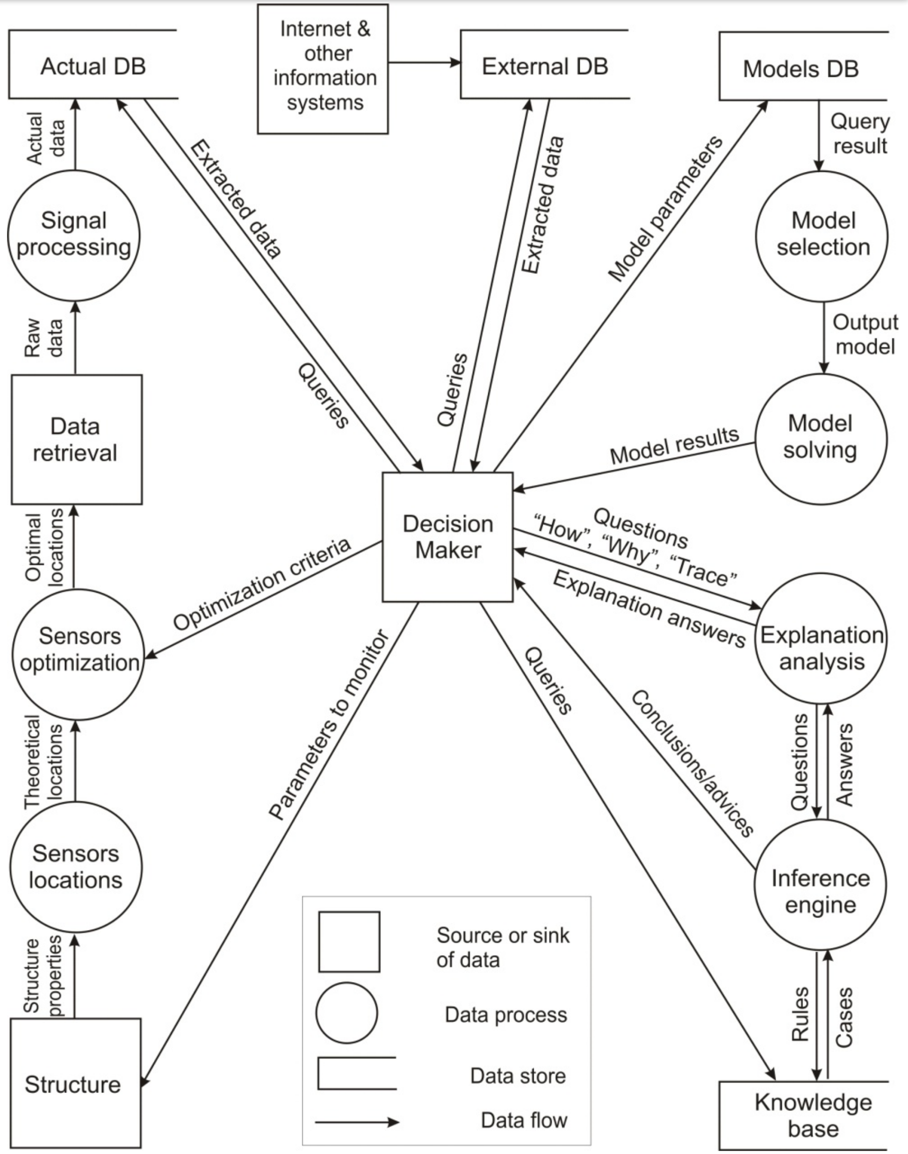
Integrated structure of DSS for predictive maintenance

- The advantages of DSS could be combined with capabilities of expert system into an integrated framework of DSS for civil engineering predictive maintenance.
- A general framework of such DSS could be compound of 4 main modules for: structure properties defining and sensors placement, structure health monitoring, structure health modeling and structure health management.



Model of data flows in DSS

- An essential step in DSS design process is to describe **how the system transforms data**. For that goal, the **data flow diagram is used to define how data is processed and stored**. It shows the points of data entry and exit and are important tool assisting in building a logical model of the designed system.
- A generalized data flow diagram of the proposed DSS is shown.



Conclusion

- The essence of the proposed decision support system framework is the ability to integrate actual information from structure health monitoring and structure health modeling modules with knowledge management in structure health management module.
- While the traditional decision support system constitutes data management, decision methodology and user interface the advances of expert system embrace symbolic reasoning and explanation capabilities. That assists decision maker in making strategic decisions by presenting information and interpretations for various alternatives.

Conclusion

- The maintenance decisions rely on not only of decision maker preferences but also on the knowledge of actual sensor data base, model base and rule base knowledge. So, to enhance the predictive maintenance a decision maker is required to exploit the capabilities of expert system in a defining a maintenance decision. The benefits of the proposed framework of decision support system for engineering predictive maintenance is in efficiency savings, only carrying out maintenance when necessary but in-time to prevent failures.
- This can often lead to substantial increases in productivity and decreasing of the maintenance costs.

Acknowledgment

The reported work is partly supported by the project **AComIn** – ***Advanced Computing for Innovation***, grant 316087, funded by the FP7 Capacity Programme (Research Potential of Convergence Regions)