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Modelling of Maintenance Services for Complex Systems

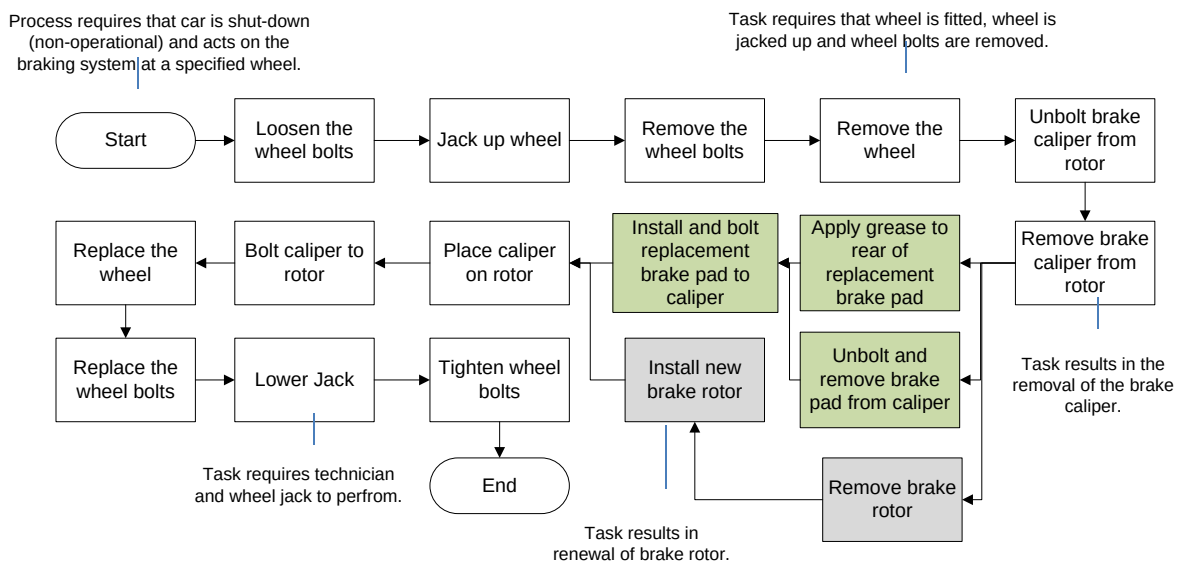
Overview:

Maintenance services must be performed to inspect and renew the condition of items (components and sub-systems) within a complex system in order to attain high levels of functional availability and safety over the asset lifetime. Performing a maintenance service involves executing multiple tasks within a certain sequence. Additionally, for reasons of efficiency, the maintenance of multiple items is often combined within the same maintenance period. The maintenance service design is complicated by the various different constraints and performance objectives that must be satisfied. The objective of this research is to develop methods for modelling the design of maintenance service for complex systems so that they can be analysed and optimised.

Description:

The maintenance service design for a system dictates how the condition of items are renewed and inspected through the execution of maintenance tasks by trained technicians. The design elements include the maintained hardware, the maintenance tasks and the maintenance process sequencing. The development of the maintenance service design is far from trivial for new or existing systems that are constructed from a high number of integrated items (subsystems and components) and have significant availability or safety requirements. Examples of such systems include aircraft, trains and process industry production lines.

The design must consider numerous constraints and performance objectives. The constraints to be satisfied for maintenance include the required configurations of hardware items, the required operational states of items and the required maintenance resources (labour, tools, facilities and spares). The performance objectives include minimising the system downtime, maintenance costs and risk. The annotated figure below shows the design of a maintenance process (tasks and sequence) for the replacement of a brake disc and pads on a car, including some of the task constraints and outcomes:



Whilst the design and optimisation of hardware reliability and maintenance policies have been the subject of vast amounts of research, the design and optimisation of the maintenance service design has received little attention. This research project aims to develop methods for modelling maintenance from a service design perspective that considers all the constraints and performance objectives discussed above and integrate them within a software tool. This tool will be designed to enable maintenance service designs to be developed, documented, explored, analysed and optimised.

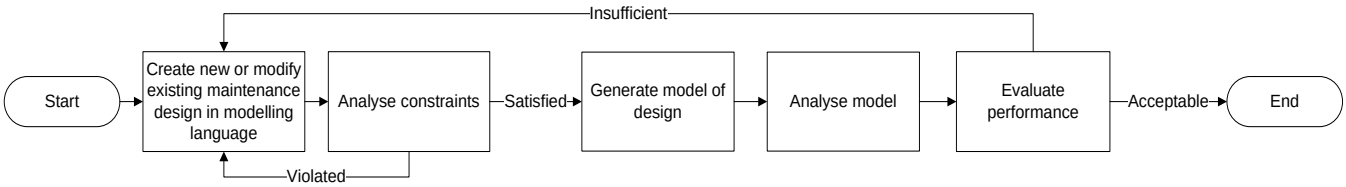
Modelling complex maintenance services can be divided into two parts:

1. The representation of the maintenance service design.
2. The execution of the maintenance service design on a hardware system or set of systems to produce performance predictions.

A modelling language, defined as a set of one or more syntaxes (graphical or textual) used to express information and knowledge, is required for the representation. A research problem in this area is finding a solution that strikes a suitable balance between generality, such that maintenance service designs for a wide range of systems can be represented, and specificity, such that the maintenance design of a particular system can be represented with sufficient detail to meet the modelling objectives. Another is finding ways to perform constraints analysis and develop computer tools that can assist with the development of new maintenance service designs (e.g. through a graphical user interface).

For the execution of maintenance on a system or systems, a methodology and computer code that can analyse any maintenance design represented using the modelling language is needed. The discrete event simulation technique is ideal for this purpose due to the inherent complexity of the processes to be modelled and the variety of detailed output data that is sought. Research problems include optimising the computational efficiency and finding suitable metrics for measuring service performance.

A modelling language and computer code for model analysis (written in C#) are currently under development. Once complete, they will be integrated with an existing tool that has been developed to model hardware reliability and maintenance strategy. The figure below shows the iterative design workflow that the research aims to enable:



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