HVAC diagnosis

- Heat Ventilation and Air-Conditioning (HVAC) systems demand continuous operation.
- HVAC systems are hybrid in nature, having multiple operation modes due to requested modes in different environmental conditions.
- Control systems will “hide” fault symptoms.
- Most solutions to automatic diagnosis were knowledge-based.
- Previous experience with model-based diagnosis in the EMWINS Project (IRUSE Modelica models).
- Look for model-based diagnosis solutions capable to cope with this kind of hybrid systems and to track transient and controlled behaviour.

The system to be diagnosed: AHU-9 (School of Music, Cork, Ireland)

- Constant air-volume Air-Handling Unit (AHU), with strict humidity and temperature conditions, controlled by Building Management System (BMS).
- AHU fault modes: parametric (sensors/change in effectiveness in components) and discrete faults (fault in commanded actuators).
- System Measurements: BMS commanded valve positions, temperature and relative humidity at input and output.

SOLUTION FOR AHU-9 USING MODEL-BASED DIAGNOSIS WITH HPCs

Model-based diagnosis using HPCs

- There are only two HPCs for the whole AHU-9 system model, both of them including most of the model equations.
- Diagnosis with HPCs deals simultaneously with both parametric and discrete faults (that will be preferred candidates).
- Discrete faults: faults in valves (df1 to df5): MB damper, Pre-HC, HC, CC, and humidifier valves.
- Parametric faults: faults in sensors (f1 to f4) or efficiency losses in some components: Pre-HC, CC and HC (f5 to f7).
- Relations between faults and HPCs can be seen through different Fault Signature Matrices (FSM).

Fault Signature Matrix: relations between parametric faults and HPCs.

<table>
<thead>
<tr>
<th>HPC</th>
<th>f1</th>
<th>f2</th>
<th>f3</th>
<th>f4</th>
<th>f5</th>
<th>f6</th>
<th>f7</th>
</tr>
</thead>
<tbody>
<tr>
<td>HPC1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>HPC2</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Results for real data (EMWINS Project)

- Tracking with numerical models for fault detection.
- Checking H-FSM for discrete faults.
- Discard /confirm discrete faults using qualitative information.
- Track fault candidates consistent with qualitative signatures in HQ-FSM.

CONCLUSIONS

- HPCs capable to track system behaviour under changing modes.
- Diagnosis using HPCs combine efficiently numerical Modelica models and qualitative information for fault detection and isolation.
- Further work is needed to automatize the whole process.

REFERENCES