PROVIDING WORLD-WIDE INTRANET ACCESS TO PRODUCT LIFETIME CALCULATIONS USING MATLAB PRODUCTION SERVER

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Bosch Transmission Technology
Using MATLAB Production Server for product lifetime calculations

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Engineering calculations at Bosch Transmission Technology

- All engineers should use the same tools.
  - Many tools are developed in house – what is the latest version?

- Quality procedures are used to develop and verify software tools.
  - Use versioning systems and (unit) tests.

- Everybody uses the same data
  - Multiple channels of communication internally and externally.

- Data can be shared between software applications.

- Effective use of computational resources.
Bosch Locations

World-Wide Engineering is the key to success!
Introduction to the CVT
Model calculations for Push Belt CVT

- Designs are made by engineers, based on user requirements:
  - Maximum torque and power, expected lifetime (kms), ratio coverage, package size.

- Detailed calculation results are shared with the customer.
  - Bosch designs and produces the push-belt only.
  - All other transmissions components are made by the customer.
  - Integration engineering.

- Calculations are made during all stages of the development process.
  - Initial offering to customer
  - Product Development.
  - Verification in Laboratory.
Engineering calculations

▶ Geometrical calculations
  ▶ Achieve a large Ratio Coverage.
    - Deep LOW is for take-off performance
    - OD is required for fuel efficiency
  ▶ Determine build size. Smaller and less weight is better.

▶ Forces and Stresses
  ▶ Calculate forces and stresses acting on the system.
  ▶ Calculate expected lifetime of the push belt
    - Number of stress cycles before most critical part fails.
Belt Calculation Model

Physical Model

BCP model

Differential Equations

Loop set part
Element string part
Pulley sheave part

± 400 elements

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Solving the BCP problem in MATLAB

```matlab
[R1,R2,exitflag] = fsolve(@(SolvVec) FuncName(SolvVec,ConstVec),InitVec,options);
```

% Call to fsolve
% Target function
% Differential equations
Implementation

Bosch PS-CT - Tilburg
- Mechanical Engineering
- Transmission Design (CVT)
- Modelling
- MATLAB

Bosch RBEI India - Bangalore
- Software Systems Design
- Databases
- Java
- MATLAB

PS-CT = Power Systems – Continuous Transmission
RBEI = Robert Bosch Engineering India
System Design

- Server stores inputs and outputs for several applications
- Start with complete variator models: BCP and VBL
- Data can be accessed by all users (engineers)
- Different interfaces and business logic for different applications.
System Implementation

Front End/Business

Java

Database

SQL

Calculations

MATLAB

Reporting

Report Server
Development – traditional design

**Bosch Tilburg**
- Product Development
- Model Development

1. Write Code
2. Test Code
3. Compile Code
4. Jar File(s)

**Bosch India**
- Software Development
- Information Systems

1. Write Code
2. Test Code
3. Compile Code
4. Create Executable

**Tilburg IT department**
- Maintain computer systems
- Install Software

1. Upload to Software Server.
2. Install JAR on users’ PC.
3. [Install MATLAB Runtime].
Local installation

Local install servers

Tilburg
Netherlands

Netherlands

Vietnam

Japan

PS-CT/EAC3 | 2018-03-05
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Drawbacks of the traditional design

Complex release process:

- Updates not synchronized due to the use of different install servers.
- Every user needs to have (correct) MATLAB Runtime installed.
- High maintenance costs (technical support).
- Sending data over the network is slow, so the performance is not acceptable.
- Changes to the MATLAB code requires rebuild of the complete code.

After the second major release, it was decided to change the design

Switch to a web-based approach
Web-based Approach

Web-server

http://BCP

Netherlands

Vietnam

Japan
**Improved Solution**

- **Make the application web-based:**
  - All required components run on a single server.
  - Only inputs and outputs are sent over the network.

- **Users do not have to install any software on local computers**
  - The database itself is used to store user data and grant access to users.
  - Use NT login credentials

- **Updating software is required at only 1 location**
  - Synchronized updates of software and database.
  - Minimal disruption of service.
  - Maximum of 1 hour downtime for major updates.
Architecture

Tomcat

BCP Java applet

MATLAB

Compiled application

Microsoft SQL Server
Initial Implementation

Server (machine)
- SQL databases
  - BCP production
  - Testing database
  - Training database

Server (machine)
- VM (4 cores)
  - Tomcat
  - BCP
  - App 2
  - App 3

Network

Only 1 process possible!
Limitations ...

Calculation Times:
Shortest : 2 seconds
Longest  : 24 hours
Infrastructure with Production Server – Final Design

Server (machine)
SQL databases
- BCP production
- Testing database
- Training database

Tilburg - NL

MPS

Matlab Production Server

Server (machine)
VM (4+ cores)
- Tomcat

Tilburg - NL

network

MPS

Worker
Worker
Worker
Main Benefits of the Matlab Production Server

- Multiple MATLAB jobs can be run simultaneously:
  - Each up to 24 hours per job (vehicle duty cycles).

- Scalable:
  - Add more cores to the server.
  - Assign different machines for different tasks.
  - Utilize available (unused) computational resources.

- Decoupling of main BCP code and MATLAB code.
  - Define inputs/outputs between systems.
  - Independent updates of Java and MATLAB code.
  - Log output is used to verify communication between the components.
Next Possible Steps

1. Make existing standard programs web-based:
   - Model-Viewer-Controller type applications.
2. Create a library of common functions, allow calling from:
   - Java, Python, C# (web)
   - Excel
   - MATLAB
3. Provide functionality to non-MATLAB departments
   - Production, Quality, Inspection, ...
4. Consider to allow customers to perform calculations
   - Eliminate iteration loops with customer
   - No access to model and data (IP)