Using Matlab production server for product lifetime calculations

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Engineering calculations at Bosch Transmission Technology BTT

- 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 applications.

- Effective use of computational resources.
BTT Locations

- **Tilburg**, Netherlands
- **Schwieberdingen**, Germany
- **Yokohama**, Japan
- **Ho Chi Minh**, Vietnam
- **San Luis Potosi**, Mexico

**Production**

**Engineering**
Introduction to the CVT
Model calculations for Push Belts

- 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.
Situation for Overdrive

± 400 elements

Pulley

Element

Loops
Force balance model

Loop set part

Element string part

Pulley sheave part
Solving the problem in Matlab

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

% function [F] = Calc_Solution_Above_Transition(x,y)
% fdmax = x(1);
% fstrek = x(2);
% beta_s = x(3);
% faxs = y(1);
% F = [Fdsec(alphas,fdmax,fstrek,b_s) + FaxsA(fdmax,fstrek,b_s) - FaxsB(fdmax,fstrek,b_s) - Mssec(fdmax,fstrek) - Ms];

% function [F] = Calc_Solution_Below_Transition(x,y)
% fdmax = x(1);
% fstrek = x(2);
% beta_s = x(3);
% faxs = y(1);
% F = [Fdsec(alphas,0.0,fstrek,b_s) - FaxsA(0.0,fstrek,b_s) + FaxsB(0.0,fstrek,b_s) - Mssec(fdmax,fstrek) - Ms];

% function [F] = Fdsec(phi,fdmax,fstrek,b_s)
% if model == BOVEN
% F = (fdmax+Csch-fstrek-Csn)*exp(-mu_lr*(alphas-b_s)))*exp(con10b*(phi-(alphas-b_s)))+(fstrek-Csn)*exp(-mu_lr*phi)-Csch;
% else
% F = (Csch-(fstrek-Csn)*exp(-mu_lr*(alphas-b_s)))*exp(con10b*(phi-(alphas-b_s)))+(fstrek-Csn)*exp(-mu_lr*phi)-Csch;
% end

% function [F] = FaxsA(fdmax,fstrek,b_s)
% if alphas-b_s < COMPZERO
% F = 0.0;
% else
% scale = 10000;
% F = scale*quadl(@(phi) dFaxsA(phi,fdmax,fstrek,scale),0.0,alphas-b_s);
% end

% function [F] = FaxsB(fdmax,fstrek,b_s)
% con20 = 0.5*(1-tan(lambda_sec)*mu_l*sin(gammalfb))/(tan(lambda_sec)*mu_l*sin(gammalfb));
% if model == BOVEN
% F = con20*((fdmax+Csch-(fstrek-Csn)*exp(-mu_lr*(alphas-b_s)))*exp(con10b*b_s)-1);
% else
% F = con20*((Csch-(fstrek-Csn)*exp(-mu_lr*(alphas-b_s)))*exp(con10b*b_s)-1);
How to Implement

BTT - Tilburg
- Mechanical Engineering
- Transmission Design (CVT)
- Modelling
- Matlab

RBEI - Bangalore
- Software Systems Design
- Databases
- Java
- Matlab

Tilburg
Netherlands

Bangalore
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

PS-CT/EAC
Product Development
Model Development

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

RBEI/ETC
Software Development
Information Systems

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

PS-CT/ICT
Maintain computer systems
Install Software

1. Upload to Software Server.
2. Install JAR on users’ PC.
3. [Install Matlab runtime].

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

Complicated 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

SQL Server
Initial Implementation

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

Tilburg - NL

VM (4 cores)
- Tomcat

Server (machine)
- BCP
- App 2
- App 3

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only 1 process!

network
Limitations ...

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

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

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

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network
Main Benefits of MPS

- Multiple Matlab jobs 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.

- Decoupled updating 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 Steps

Three developments:

1. Make existing standard programs web-based:
   - Model-Viewer-Controller type applications.

2. Create a library of common functions, allow calling from:
   - Java (web)
   - Excel
   - Matlab

3. Provide functionality to non-Matlab departments
   - Production, Quality, Inspection, …