

Integrating the PI System with Third-Party Analytics

Presented By:

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Why Choose the PI System? Analytics

The PI System has the data – What's the next step?

- **Business intelligence:** optimizing production
- **Process control:** nominal trajectory
- **Data mining:** fault detection and prevention
- **Complex event processing:** notification



PI Analytics Subset

Performance Equations

Totalizers

Alarm/Statistical Quality Control

PI Advanced Calculation Engine

PI for StreamInsight*

AF-supported Analytics*

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3rd-Party Analytics

Excel Solver: Datalink, PI-SDK

- Made by Frontline Systems
- Good for smaller setups
- Meshes well with PI-Datalink

The screenshot shows an Excel spreadsheet with the following data:

| | Mineral 1 | Mineral 2 |
|---------------------------------------|-----------|-----------|
| Units of substance A in the minerals: | 1 | 1 |
| Units of substance B in the minerals: | 3 | 0.2 |
| Units of substance C in the minerals: | 0.5 | 2 |
| Minimum levels of minerals: | 0 | 0 |

Summary of costs and units:

| Item | Value |
|-------------------------------|----------|
| Total cost: | 777.5683 |
| Per-unit cost of mineral 1: | 9.719861 |
| Current units of mineral 1: | 80 |
| Per-unit cost of mineral 2: | 79.57586 |
| Current units of mineral 2: | 0 |
| Current level of substance A: | 80 |
| Current level of substance B: | 240 |
| Current level of substance C: | 40 |

Mineral purchase problem:

There are two minerals to be purchased at variable per-unit through Datalink. There are three substances A, B, and C at different levels of the substances in it (B8-C10). We have to get the production to go forward (J8-J10).

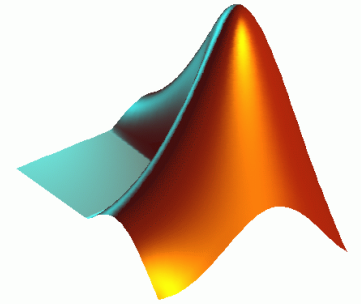
The decision factors are how many units of each mineral while meeting the constraints.

This problem is also known as the "diet problem" where we minimize the cost by choosing our diet basket.

3rd-Party Analytics

MATLAB[®] by Mathworks

- ADO and PI OLEDB Provider
- OPC toolbox and PI OPC
- Database toolbox and PI JDBC Driver
- COM Automation Server referenced in codes using PI SDK or PI ACE



3rd-Party Analytics

JMP Statistical discovery by SAS



- Provides visual statistical data on the desktop
- MS Excel and PI DataLink
- ODBC and PI ODBC Client
- Flat text files and `piconfig` utility

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Use Case: Mathematical Optimization

Business Intelligence

- Minimizing production cost

Process Control

- Verification of a process controller/DCS against nominal trajectory

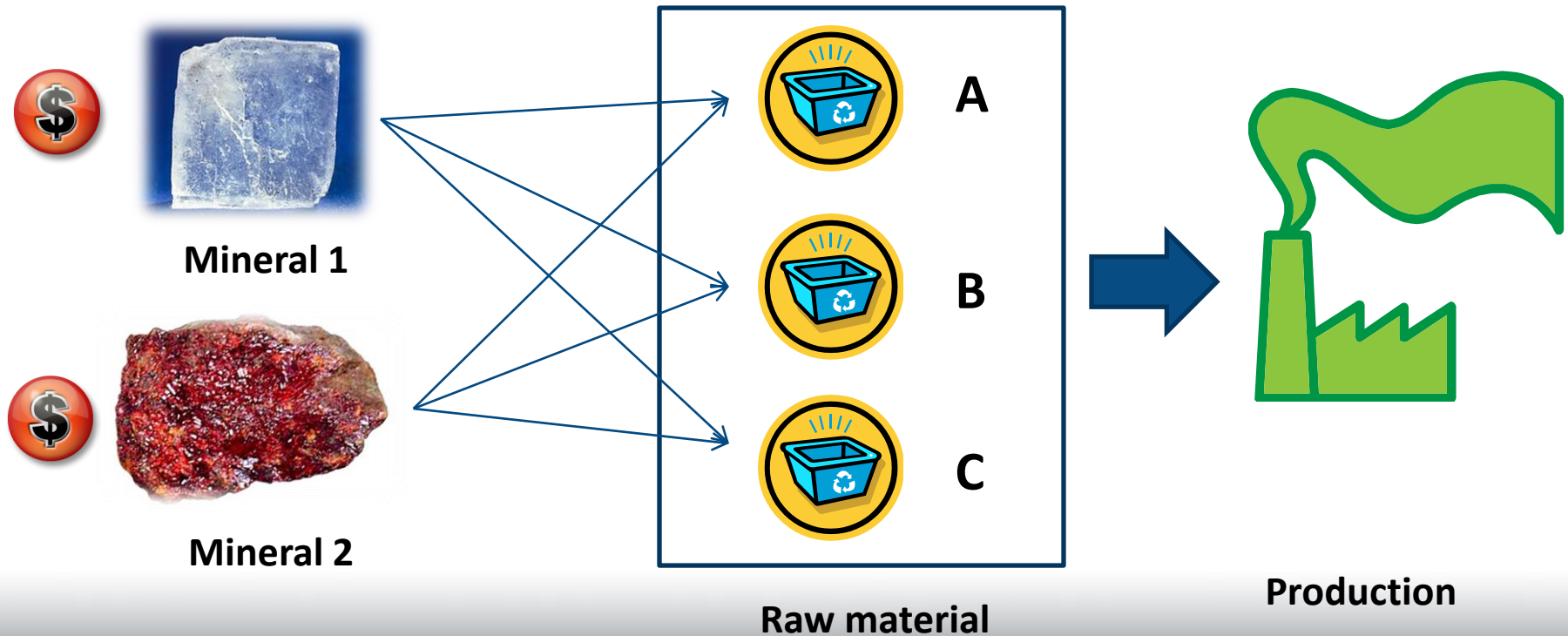
Data Mining and Curve Fitting

- Preemptive fault detection and forecasting



Example: Solver add-in to Microsoft Excel

- Minimizing cost of raw material




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Example: Solver add-in to Microsoft Excel

- **Objective:**
minimize the cost of minerals
- **Constraints:**
minimum levels of each material



- **The PI System:**  different parameters come through PI DataLink in real-time
- **Excel Solver:**
optimization

Example: Solver add-in to Microsoft Excel



Excel solver example-Diet Problem.xlsx - Microsoft Excel

File Home Insert Page Layout Formulas Data Review View Developer Add-Ins

From Access From Web From Text From Other Sources Get External Data Existing Connections Refresh All Properties Edit Links Connections Sort & Filter Sort Filter Clear Reapply Text to Columns Remove Duplicates Data Validation Consolidate What-If Analysis Group Ungroup Subtotal Show Detail Hide Detail Solver

A3 Total cost:

| | A | B | C | D | E | F | G | H | I | J | K | L |
|----|---------------------------------------|-----------|-----------|---|-------------------------------|----------|---|---|--------------------------------|----|---|---|
| 1 | | | | | | | | | | | | |
| 2 | | | | | | | | | | | | |
| 3 | Total cost: | 7409.34 | | | | | | | | | | |
| 4 | Per-unit cost of mineral 1: | 93.61686 | | | Per-unit cost of mineral 2: | 74.49603 | | | | | | |
| 5 | Current units of mineral 1: | 80 | | | Current units of mineral 2: | 0 | | | | | | |
| 6 | | | | | | | | | | | | |
| 7 | | Mineral 1 | Mineral 2 | | | | | | | | | |
| 8 | Units of substance A in the minerals: | 1 | 1 | | Current level of substance A: | 80 | | | Minimum Levels of substances A | 50 | | |
| 9 | Units of substance B in the minerals: | 3 | 0.2 | | Current level of substance B: | 240 | | | Minimum Levels of substances B | 30 | | |
| 10 | Units of substance C in the minerals: | 0.5 | 2 | | Current level of substance C: | 40 | | | Minimum Levels of substances C | 40 | | |
| 11 | | | | | | | | | | | | |
| 12 | | | | | | | | | | | | |
| 13 | Minimum levels of minerals: | 0 | 0 | | | | | | | | | |
| 14 | | | | | | | | | | | | |
| 15 | | | | | | | | | | | | |
| 16 | | | | | | | | | | | | |
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| 30 | | | | | | | | | | | | |
| 31 | | | | | | | | | | | | |

Mineral purchase problem:

There are two minerals to be purchased at variable per-unit prices (B4 and F4) that come from PI in real time through Datalink. There are three substances A, B, and C necessary for production. Each mineral contains some different levels of the substances in it (B8-C10). We have to meet some minimum levels of each substance for the production to go forward (J8-J10).

The decision factors are how many units of each mineral we buy (B5, F5). The goal is to minimize total cost (B3) while meeting the constraints.

This problem is also known as the "diet problem" where we need to receive certain levels of different nutrients while minimizing the cost by choosing our diet basket.

Example: Solver add-in to Microsoft Excel

Set up of
the problem:

The screenshot shows the 'Solver Parameters' dialog box with the following settings:

- Set Objective:** \$B\$3
- To:** ☐ Max ☒ Min ☐ Value Of: 0
- By Changing Variable Cells:** \$B\$5:\$F\$5
- Subject to the Constraints:**
 - \$B\$5 >= \$B\$13
 - \$F\$10 >= \$J\$10
 - \$F\$5 >= \$C\$13
 - \$F\$8 >= \$J\$8
 - \$F\$9 >= \$J\$9
- ☒ Make Unconstrained Variables Non-Negative
- Select a Solving Method:** Simplex LP
- Solving Method:** Select the GRG Nonlinear engine for Solver Problems that are smooth nonlinear. Select the LP Simplex engine for linear Solver Problems, and select the Evolutionary engine for Solver problems that are non-smooth.

Buttons at the bottom: Help, Solve, Close.

Mathworks MATLAB®

The PI System

- Provides historical data

MATLAB

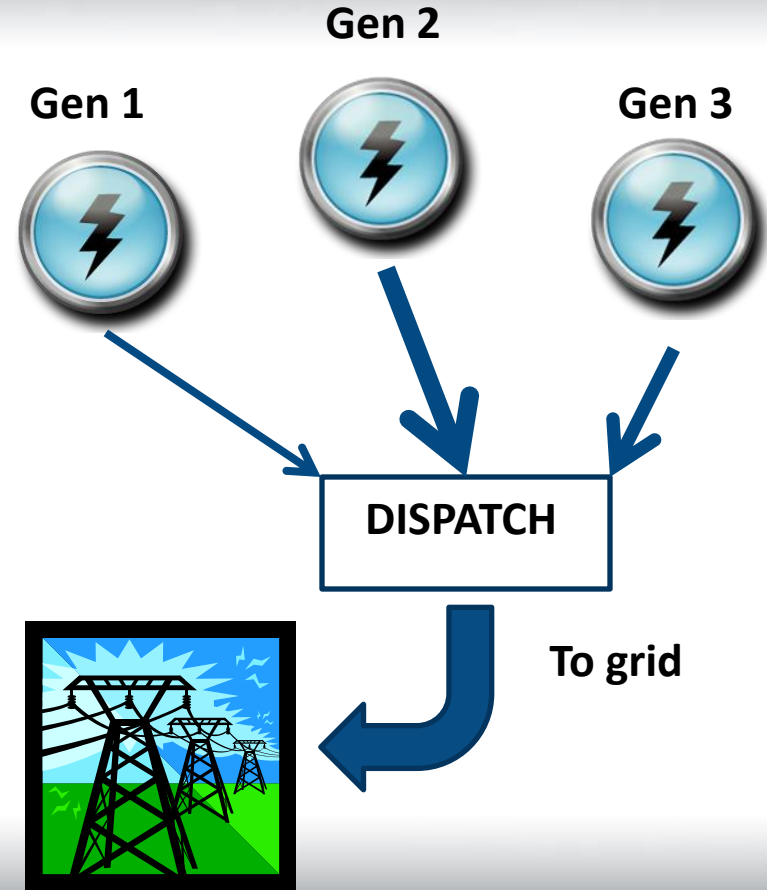
- Performs analysis

- Data analysis and modeling, application and algorithm development

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Example: Economic Dispatch

- Several production units, variable costs
- Given: power demand
- Question: How to allocate the production



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Example: Economic Dispatch

Objective: minimize total production cost

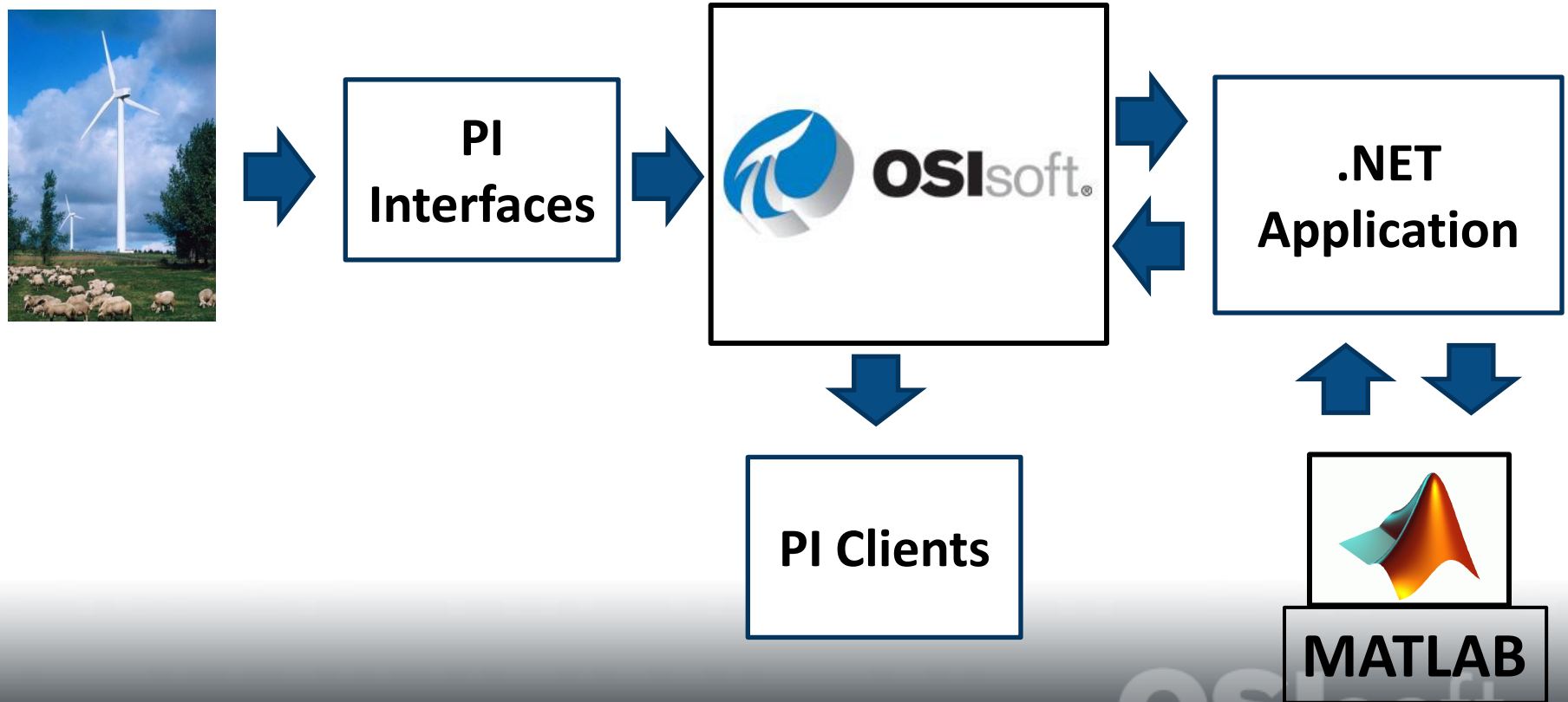
Constraints:

- Total generation less than demand
- Individual production cap
- Other constraints

Decision: how much each unit generates

Example: Economic Dispatch

Data flow:



Example: Economic Dispatch

- Cost: $\sum_i c_i P_i^2 + b_i P_i + a_i - \pi P_i$
- Subject to: $0 \leq P_i \leq P_i^{max}$
$$\sum P_i \leq P_d$$

| | |
|-----------------|-----------------------------|
| P_i | Production at generator i |
| P_d | Demand |
| π | Going price at the market |
| a_i, b_i, c_i | Cost coefficients (from PI) |

Example: Economic Dispatch

A server object in PI-SDK to access PI points
(`Data.Snapshot.Value`)

“MATLAB COM automation sever” is referenced

Arrays (matrices) are passed
“MATLAB.Application” object

“quadprog” function in optimization toolbox

Example: Economic Dispatch

Benefits

Convenient
access to
enterprise
data in real-
time

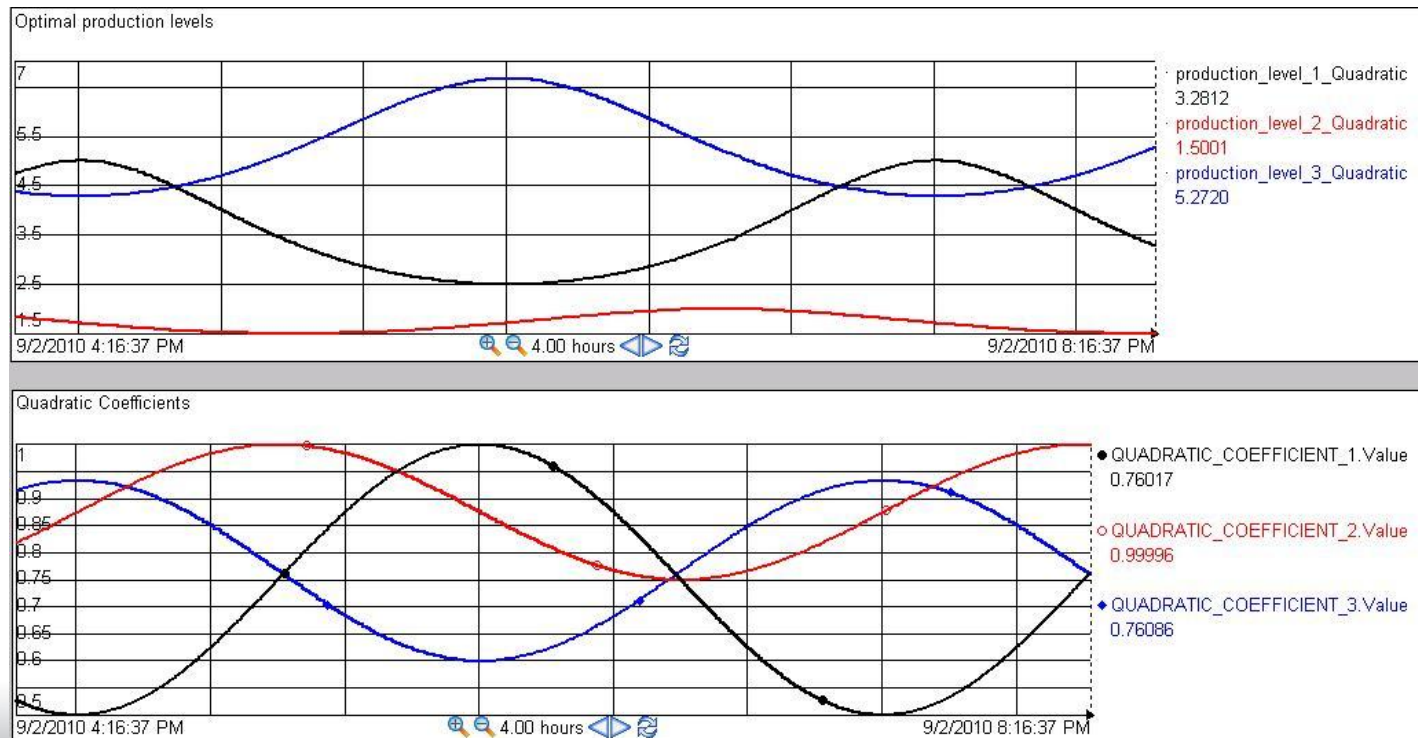
Easy
manipulation
of complex
analytics;
suitable for
large scale
problems

Having
optimal
results in
real-time

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Example: Economic Dispatch

Implementation results



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Concluding Remarks

The PI System provides several analytical tools

The PI System could conveniently combine with 3rd party analytical tools as well

Optimization problems can boost the whole enterprise via complex optimal results in real-time





Thank You!

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