**Teaching Case**

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**Article Link:** [https://jise.org/Volume33/n3/JISE2022v33n3pp229-231.html](https://jise.org/Volume33/n3/JISE2022v33n3pp229-231.html)

Initial Submission: 20 May 2021  
Minor Revision: 6 October 2021  
Accepted: 20 October 2021  
Published: 15 September 2022

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ISSN: 2574-3872 (Online) 1055-3096 (Print)
Teaching Case

Widgets-R-Us: Using IoT to Monitor Part Levels

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ABSTRACT
This teaching case describes the functionality of a system employing IoT sensors to monitor part levels for a fictitious auto parts manufacturer. Data from the sensors are used to populate a centralized database and generate a dashboard for management. The system also generates tiered alerts to notify part runners and managers of pending part shortages. The case is based on an actual systems development project that students completed for a real auto parts manufacturer. Material in the case can be used for assignments in systems analysis and design, database management, and data analytics courses. Teaching notes, including an entity-relationship diagram (ERD), data dictionary, data flow diagrams, prototype dashboard, and discussion questions are available through the JISE website.

Keywords: Database design & development, Entity-relationship modeling/diagram, Systems analysis & design, Data flow diagram, Data analytics, Teaching case

1. INTRODUCTION
Widgets-R-Us is a small, midwestern, auto parts supplier. Founded in 1967, Widgets-R-Us specializes in Original Equipment Manufacturer (OEM) products for auto manufacturers such as Ford, GM, FCA, and Honda. Widgets-R-Us produces three products (A, B, and C) in its factory in Mount Pleasant, Michigan. Each product is manufactured on its own assembly line on the factory floor. The assembly of each product is a multi-step process involving multiple workstations and numerous component parts. As an established company in the auto parts market, Widgets-R-Us has long had a reputation for producing quality products in a timely manner. Unfortunately, this reputation has recently come into question as the company has missed some deliveries due to a slow-down in production. This slow-down is directly related to the company’s addition of Product C – its newest product line. Since Product C was introduced, overall production levels have dipped causing the company to miss delivery deadlines. To address this issue, Widgets-R-Us hired a new production manager who has just completed a review of the factory’s manufacturing process. Based on this review, the manager believes she has determined the source of the problem, namely, the current process used to resupply parts to the workstations. The manager has decided to rework this process by implementing Internet of Things (IoT) sensors and a real-time dashboard to collect and display data about part levels in the three production lines. These changes are expected to cut the number of part stock-outs, resulting in increased production at the factory and a return to timely deliveries.

2. BACKGROUND
For this case, the students will assume the role of system analysts responsible for designing and implementing a system to capture, display, and report parts data from the factory’s production lines. Data will be captured in real-time using IoT sensors. The captured data will be displayed using a dashboard simulating the manufacturing floor. The dashboard will also allow the production manager to generate reports from the system database. Finally, the system will notify employees and management of impending stock-outs so they can resupply parts proactively.

3. CASE TEXT
3.1 Overview of the Current Workstation Replenishment Process
The Widgets-R-Us factory operates 24/7 with three shifts: day, mid, and night. The factory has three assembly lines, one for each product. Each of the lines has multiple workstations. At each of these workstations there can be any number of racks. These racks hold the parts that the employee at that workstation uses for their portion of the assembly process. To simplify its inventory, Widgets-R-Us puts all parts used at a workstation in the racks, whether parts by the piece or in bulk. Each rack holds up to three trays of a specific part. The trays are organized in
The first position is painted red. This is for the tray closest to the worker – the tray parts are being pulled from. The second position is painted yellow. This is for the first reserve tray. The third position is painted green. This is for the second reserve tray. If the part runners check a rack and see the last tray in the yellow position, they need to get parts.

As an example, for Product A on Line 1 there are three workstations. The first workstation has two racks. The first rack contains trays for Widget-A housings, 10 housings per tray. The second rack contains trays for Widget-A motors, 8 motors per tray. The worker at this station would assemble the housing and the motor and send that sub-assembly to the next workstation. The second workstation on Line 1 has two racks. The first rack contains trays for Widget-A covers, 20 covers per tray. The second rack contains trays with rubber seals, 100 seals per tray. When the worker at this station gets the sub-assembly from the first workstation, their job is to put a rubber seal in a cover and affix the cover to the sub-assembly. After completion of this operation, the sub-assembly is sent to the last workstation. The last workstation on Line 1 contains two racks. The first rack contains trays with M10-1.25x50 flanged hex head bolts, 100 bolts per tray. The worker uses 5 bolts to affix the cover to the housing. The completed product is then placed in a tray in the second rack. Currently, Widgets-R-Us has “part runners” whose job is to walk the manufacturing floor, checking to see which workstations need to be resupplied with parts. Given the number of lines, workstations, and racks, this can be challenging. In order to help the part runners, the racks have been painted with a different color for each position of a tray. Since it is possible to have three trays on a rack, the tray positions are painted red, yellow, and green (see Figure 1).
3.3 Alerts
The system will generate tiered alerts when part levels drop below acceptable levels. First-tier alerts will be sent when a rack has only one tray in reserve (condition yellow). These alerts will be sent via text message to the part runner currently on duty. They will identify the workstation and part that needs to be replenished, along with the rack into which the part tray should be placed. Second-tier alerts will be sent when a rack has no trays in reserve (condition red). These alerts will be sent to the part runner via text message and the production manager via email. Second-tier alerts will also be displayed on the production manager’s dashboard. Finally, third-tier alerts will be sent when a rack is empty. These alerts will be sent to all available managers via email, in addition to text messages sent to the part runner and the production manager. Third-tier alerts will also be displayed on the production manager’s dashboard. Third-tier alerts are obviously very serious since they mean that work on a product line has, effectively, come to a halt.

3.4 Reports
The system will provide a set of both canned and ad-hoc reports for use by Widget-R-Us’ management. The students are tasked with defining and developing the reports based on the business needs described in the case and the specific data captured through their system design.

4. ASSIGNMENT
The Widgets-R-Us case can be used to develop a number of possible assignments. These assignments can be completed by individuals or groups. They can be used to create multiple homework assignments or one comprehensive system design project. The authors provide examples of possible assignments in Table 1.

<table>
<thead>
<tr>
<th>Class Activity</th>
<th>Assignment</th>
<th>Deliverables</th>
</tr>
</thead>
<tbody>
<tr>
<td>System requirements lecture, Review Widgets-R-Us case</td>
<td>Document system requirements</td>
<td>System requirements document</td>
</tr>
<tr>
<td>ERD lecture, Review Widgets-R-Us case especially factory entities (line, workstation, rack, etc.)</td>
<td>Develop data model</td>
<td>ERD</td>
</tr>
<tr>
<td>DFD lecture, Review Widgets-R-Us case especially input from IoT sensors and alerts to management</td>
<td>Model system processes</td>
<td>DFD</td>
</tr>
<tr>
<td>User interface design lecture, Review Widgets-R-Us case especially dashboard layout</td>
<td>Develop desktop prototype</td>
<td>Desktop application forms</td>
</tr>
<tr>
<td>IoT lecture, Review Widgets-R-Us case especially data collection</td>
<td>Document rules for when sensors should report</td>
<td>Program code to insert sensor data into database and</td>
</tr>
</tbody>
</table>

| Data analysis lecture, Review Widgets-R-Us case especially performance metrics (number of stock-outs, time to replenish, etc.) | Analyze sensor data to produce performance metrics | Performance report with suggestions for improving the production process |

Table 1. Possible Assignments

5. CONCLUSION
The case presented herein provides numerous opportunities to engage students in a real-world system design problem. Students working as individuals, or in groups, can tackle assignments ranging from documenting requirements to designing databases and dashboards. Students can perform data analysis using IoT sensor data and even complete a hardware-based assignment to collect the data in real-time. The assignments can be completed as stand-alone exercises or combined to create a complete system design project.

The case is based on a systems development project that students completed for a real auto parts manufacturer. Widgets-R-Us may be fictitious but the scenario is not. IoT has become a significant part of the manufacturing industry and its use is only expected to grow. Students will benefit from their exposure to a real-world case and the challenges it presents.

AUTHOR BIOGRAPHIES

Paul Dunn is a lecturer in information systems at Central Michigan University. He received his Master’s in Information Resource Management from Central Michigan University. He has over 20 years of experience in client/server programming, database design and administration, and system administration. His research interests are big data, NoSQL, and data analytics.

Robert Miller is a professor of information systems at Central Michigan University. He received his Ph.D. in Information Systems from the University of Arkansas. His current research interests include information systems service quality, social media, and faux pas posting. His publications have appeared in several journals including Behaviour and Information Technology, Information Systems Management, Journal of Information Systems Education, and MISQ Executive.
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