TECHNOLOGY IN ACTION™

Raspberry Pi Retail Applications

Transform Your Business with a Low-Cost Single-Board Computer

—

Elaine Wu
Dmitry Maslov

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Elaine Wu
Shenzhen, China

Dmitry Maslov
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Any source code or other supplementary material referenced by the author in this book is available to readers on the Github repository: https://github.com/Apress/Raspberry-Pi-Retail-Applications. For more detailed information, please visit http://www.apress.com/source-code.

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Table of Contents

About the Authors

Elaine Wu specializes in business partnerships and marketing in various tech industries, from software to embedded hardware. She is currently the marketing and partnership manager at Seeed (an open-source AIoT hardware platform) where she focuses on the global IoT solution ecosystem, making technology accessible for all. At Seeed, by aligning with partners and best hardware, she believes and strives on the path of the most reliable hardware platform, empowering everyone to achieve their digital transformation goals. She was also leading community partnerships, content marketing, new products' go-to-market strategies at Seeed before 2021. Elaine is an active article contributor at Seeed blog on a variety of industries topics, including but not limited to SBCs, microcontrollers, ML/AI, robotics, and SLAM.

Dmitry Maslov works professionally in applied machine learning and robotics. He has spearheaded a variety of machine learning projects, both for previous employers and as a freelancer. Proficient in Python and C/C++, Dmitry has an excellent knowledge of ROS and ROS-i. He speaks four languages, with professional fluency in three. Dmitry is the owner of Hardware.ai, a YouTube channel where he publishes videos on creating intelligent systems with machine learning and ROS on single-board computers.

About the Technical Reviewer

Massimo Nardone has more than 22 years of experience in security, web/mobile development, and cloud and IT architecture. His true IT passions are security and the Android platform.

He has been programming and teaching others how to program with Android, Perl, PHP, Java, VB, Python, C/C++, and MySQL for more than 20 years.

He holds an MS in Computing Science from the University of Salerno, Italy.

He has worked as a project manager, software engineer, research engineer, chief security architect, information security manager, PCI/SCADA auditor, and senior lead IT security/cloud/SCADA architect for many years.

CHAPTER 1

Understanding the Applications of Automation in Retail

What are some of the most pressing issues that owners of small- and medium-sized businesses currently face?

These concerns include the growing costs of supply chains, increasing costs of labor and capital, and increased spending on equipment upgrades and business strategy re-evaluations necessitated by competitors and changes in the business environment. It is very important for small business owners to have solid and practical solutions for saving money on manufacturing processes and labor. They need to increase efficiency and widen the margin in both directions—by eliminating unnecessary expenses and by increasing revenues.

With the development of Industry 4.0, the automation of business retail applications has been gaining interest and popularity. Automation in retail applications reshapes the business models, from the backend supply chain to the frontend of business management, which not only helps business owners save on labor costs, but also helps with efficiency. With automation, customers can have a better experience in an easier way.

E. Wu and D. Maslov, *Raspberry Pi Retail Applications*,
https://doi.org/10.1007/978-1-4842-7951-9_1

What Is Industry 4.0?

Industry 4.0, the fourth industrial revolution, refers to the ongoing digital transformation of industries, such as combining human machine interface (HMI) and cloud data to build digital solutions to make the industrial model more efficient (see Figure 1-1). Compared to the preceding industrial revolutions, Industry 4.0 focuses on the digital, information-driven interconnectivity among people, devices, and systems, which enables enhanced decision making in industrial processes. At the same time, due to this digital transformation, customer expectations are rising. Retailers are striving to adapt and survive in a competitive environment. With Industry 4.0, a lot of new skills must be added to the development and manufacturing process, such as machine learning capabilities, edge computing, and remotely visualized dashboards using cloud businesses. Retail owners at the same time must use new technology to make solid decisions about hardware and software.

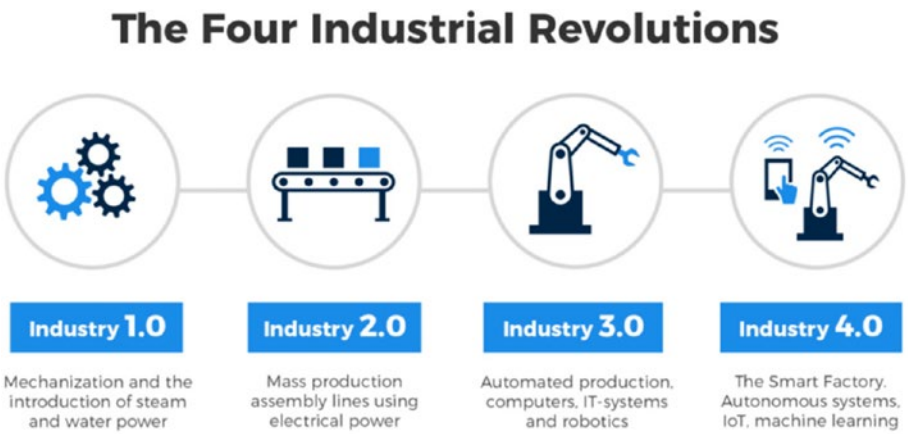

Figure 1-1. *The four industrial revolutions. Source: Spectral Engines*

McKinsey & Company, "COVID-19: An Inflection Point for Industry 4.0" is a survey of more than 400 global manufacturing companies. A full 94% of the respondents said that Industry 4.0 helped them to maintain operations during COVID-19 (starting from the end of 2019), and 56% of the respondents said that digitization was crucial to responding to the pandemic. See Figure 1-2.

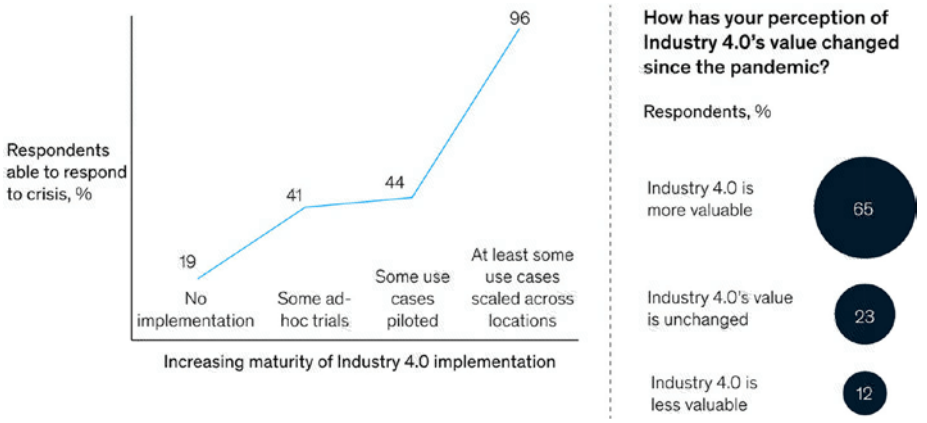

Figure 1-2. *Companies that implemented Industry 4.0 report a stronger ability to respond to pandemic crises. Source: McKinsey & Company, "COVID-19: An inflection Point for Industry 4.0"*

According to Deloitte's report (see Figure 1-3), Industry 4.0 originated in Europe and developed rapidly in Germany's manufacturing sectors. Across the United States, Industry 4.0 may be translated into the concept of "industrial Internet" and "Internet of Things." Since the 1970s, industrial progress has increasingly embraced automation.

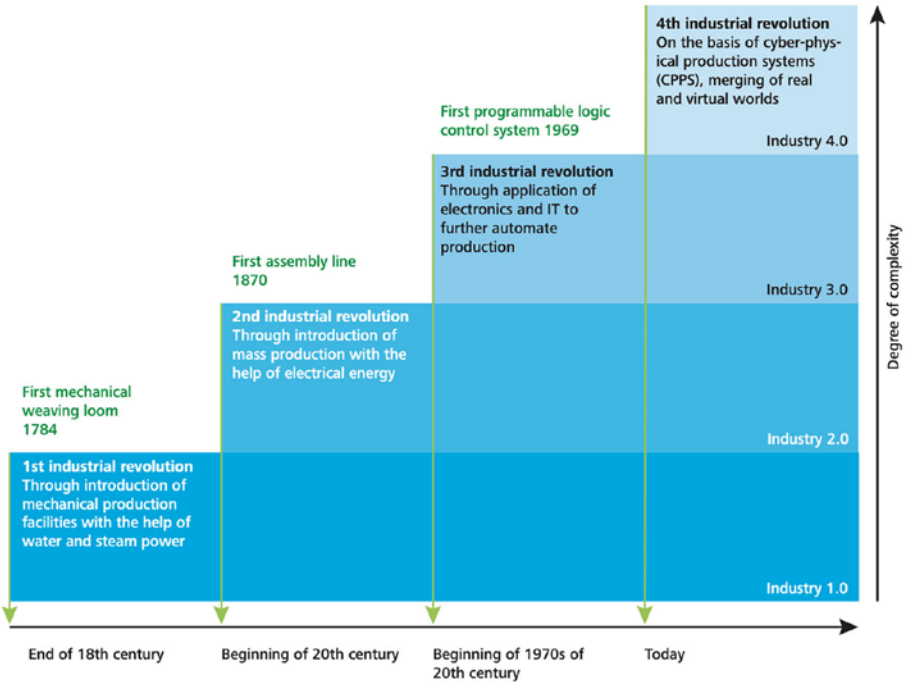

Figure 1-3. *Definition of Industry 4.0. Source: Deloitte*

We believe that single-board computers such as the Raspberry Pi can motivate and inspire retailers to faster digital transformation, because the Raspberry Pi lowers the barriers from development to deployment. In the longer term, when large enterprises need transformation and small retail businesses need expansion, companies also need to invest in the appropriate infrastructure, such as research and development (R&D) and procurement units, in order to successfully realize the digital transformation of Industry 4.0. Procurement, production, warehousing, and logistics are at the core of the digital transformation of Industry 4.0, as everything becomes convenient. Sales and service departments stand to gain the most from the result of Industry 4.0. In these market segments, more customized solutions can bring the manufacturing and retail business industries into a new era of customization.

What Is the Internet of Things (IoT)?

The Internet of Things (IoT) is the connection between the digital world and the physical world. IoT is a network of physical objects ("things") embedded with sensors, software, and other technologies, which helps exchange data with devices through different communication networks. These devices can come from households (lamps, speakers, and kitchen tools) or from industrial machines (manufacturing equipment and fleets). IoT syncs the digital world and real-world data. This digitization of the physical world is creating new value for customers.

The potential economic value that IoT may realize is huge and growing. It is estimated that by 2030 (McKinsey & Company, "Potential Economic Value of the IoT"), including the value that consumers obtain through IoT products and services, IoT is expected to create a value of 5.5-12.6 trillion U.S. dollars worldwide.

Which Technologies Make the Internet of Things More Accessible in the Retail Industry?

- *Low-cost, low-power sensors:* Devices can collect environmental changes, motion, and other data in the retail environment to help retailers make better decisions faster.
- *Real-world data collection:* Machines supporting IoT can initiate commands, such as payment and identification commands.
- *Ubiquitous connectivity:* A large number of connection protocols—such as BLE, WiFi, Zigbee, LoRa, LTE, and 5G—make it more efficient and cost-effective to connect sensors to devices, the cloud, and to "things" around us.

- *Cloud computing platform:* The cloud platform ensures the stable operation of the infrastructure. The cloud platform provides fully managed services, ingesting and processing the data from millions of distributed devices around the world.
- *Machine learning integration:* Embedded machine learning helps to operate and analyze massive amounts of data much faster. Business owners can gather insights easier with reliable data models.
- *Speech recognition:* Natural language processing (NLP) integrated into IoT devices can be deployed directly in offices and homes as home automation.

According to Microsoft's industry blog, *"5 IoT Retail Trends for 2021,"* Carl Norberg, Founder of Turnpike, stated "We realized that by connecting store IoT sensors, POS systems, and AI cameras, store staff can be empowered to interact at the right place at the right time."

McKinsey & Company's research ("IoT Value Set to Accelerate Through 2030") in November of 2021 demonstrated that the IoT offers significant economic value potential through 2030. In the retail environment, the research predicted that self-checkouts (billing, payments, and material handling) and real-time personalized promotions will be the top uses for retail industry adoption of IoT. See Figure 1-4.

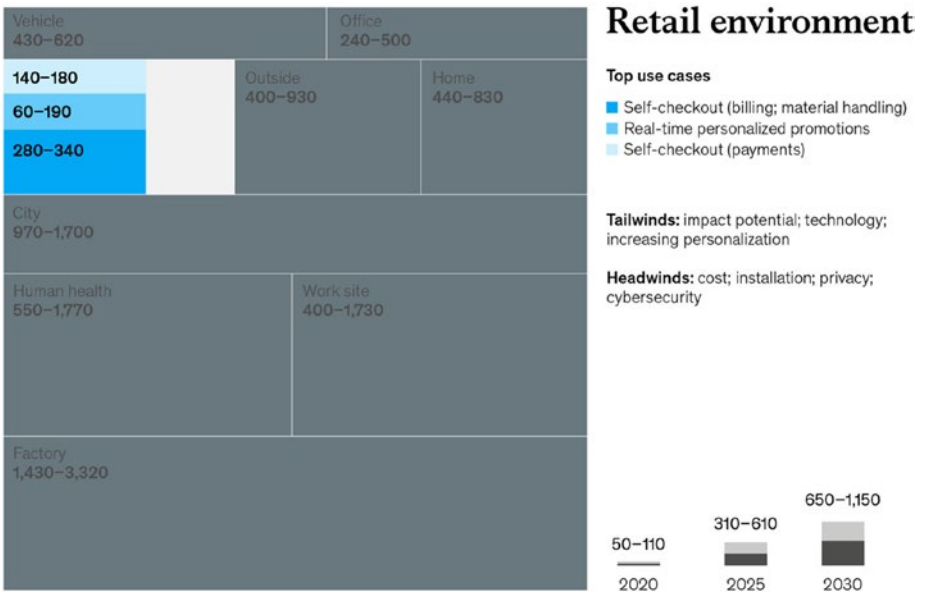

Figure 1-4. *Estimated 2030 economic value of IoT adoption, by setting, billion dollars, retail environment segment. Source: McKinsey & Company, "IoT Value Set to Accelerate Through 2030"*

Although the potential economic value of IoT is considerable, the actual deployment and final transformation are equally challenging, especially in a B2B (business-to-business) environment. Many companies have been struggling to transition from pilot projects to successful large-scale deployments in order to obtain breakthrough value.

The IoT technology is connecting the digital world to the physical world. Manufacturers and companies may take advantage of IoT to improve operations, manage tangible assets, and enhance customer experience. IoT is becoming the core of digital transformation. There has also been an increasing need for industrial-grade IoT products, as many industries are going through the digital transformation.

Based on the research of well-known consulting companies, authors' experience in the IoT field, and familiarity with latest hardware

resources, we hope to give employers in the retail industry who are still in the exploring stage confidence to move to the proof of concept (PoC) stage now, as well as help retail employers accelerate their digital transformation.

Amazon Go Grocery Store: Ambitiously Implementing Automation

If you visit an Amazon Go grocery store, you will find that there are no human interactions. You just walk in, scan the QR codes with the Amazon mobile app, put anything you want to purchase into your basket, and finally walk out when you are finished shopping. The store only staffs a few employees to inventory shelves and answer shoppers' questions, but there is almost no human interaction (see Figures 1-5 and 1-6).

> *Amazon reportedly had been forecasting annual revenue from all Amazon Go stores would skyrocket from $28 million in 2018 to upwards of $639 million in 2020, according to The Information. But Amazon hasn't opened as many Go stores as it had initially anticipated, the report said. And operating losses from Go are still ballooning, it said.*
>
> —CNBC: "Amazon is opening its first full-size, cashierless grocery store. Here's a first look inside"

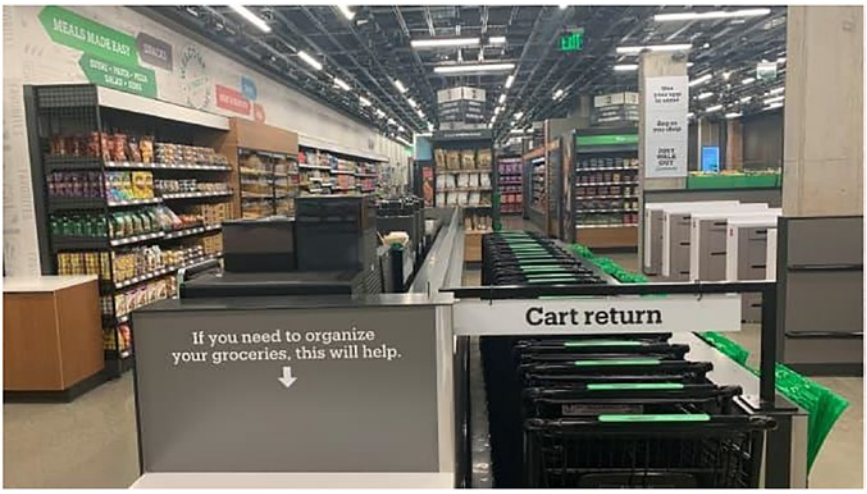

Figure 1-5. *The "just walk in, just walk out" technology builds on what Amazon has learned with its smaller Go stores. Source: Lauren Thomas, CNBC*

Figure 1-6. *Amazon Dash Cart. Source: Amazon*

The Amazon Dash Cart (see Figure 1-6) helps with the "walk-in and walk-out" process launched by Amazon's Go store. There are hundreds of cameras on the ceiling to track your every move. In your basket, there is a built-in scale, cameras, and sensors to calculate what you put in the basket. A Dash Cart can hold two bags. When you finish your purchase, Dash Cart links to your Amazon account to deduct the corresponding payment. There is a screen on the top to display the shopping list and you can even scan coupons. Can you implement the Dash Cart idea by using Raspberry Pi and sensors and deploy it with machine learning? Later chapters will return to this question.

Why Choose a $35 Single-Board Computer to Automate a Retail Business?

It is surprising that, with a $35 credit card-sized, single-board computer, retailers can increase productivity and lower operational costs. This is possible simply by automating crucial business processes.

Raspberry Pi, the most popular and affordable credit card-sized, single-board computer, is available in multiple form factors. You can get it as a development board, as a system on module (SoM), and as an all-in-one personal computer kit with a keyboard. Figures 1-7 through 1-9 show various aspects of the Raspberry Pi board.

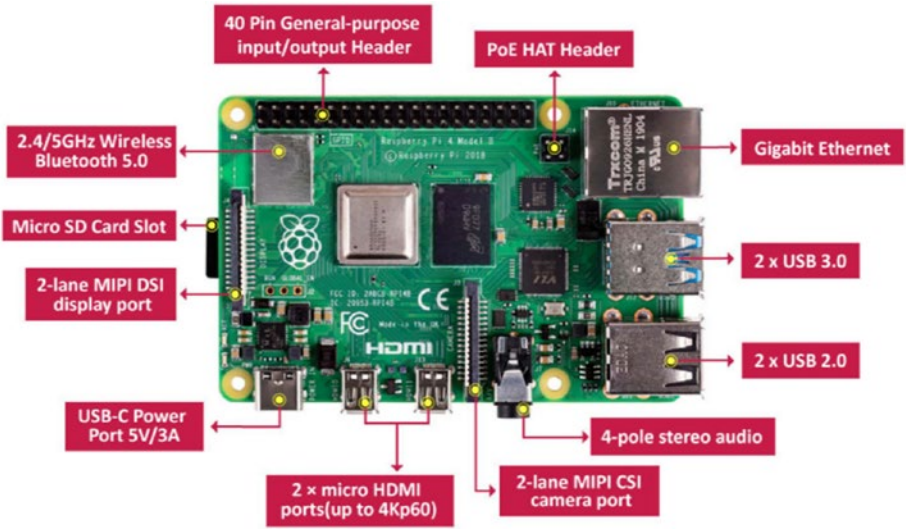

Figure 1-7. *Raspberry Pi 4 hardware overview. Source: Seeed*

Figure 1-8. *Raspberry Pi 400 | All-In-One RPI with keyboard and mouse, reviewed by Seeed. Source: Seeed*

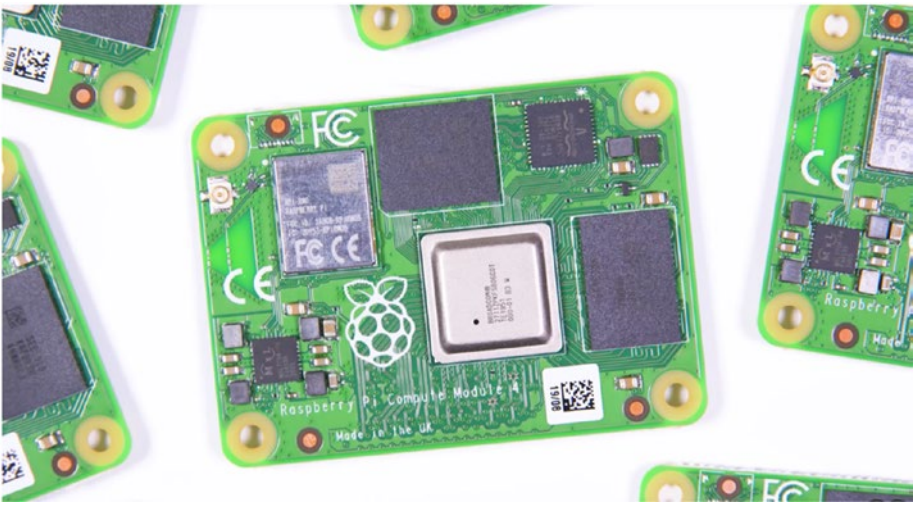

Figure 1-9. *The new Raspberry Pi Compute Module 4 by Raspberry Pi. Source: Raspberry Pi*

Whether you are still developing ideas to transform your business or you have an idea but lack the skill to implement it, this book is an invaluable resource for you to navigate the ever-changing landscape of retail automation.

Identify the Targets for Business Automation

What can automation do at the current level of technical progress? This list explains many of the current targets of automation:

- *Predictive analysis:* This is a common approach to managing and automating business processes. It can be also used to automate routine tasks in retail businesses by replacing human decisions with machine decisions. One of the most powerful use cases is the automation of routine decisions based on big data analysis.

Retailers can use machine vision algorithms to detect the movement of customers in the store. These algorithms detect when a customer enters the store, when a customer leaves the store, when a customer is walking in the store, when a customer is walking toward or away from a product, when a customer stops near a product, and so on.

- *Tracking and analyzing data from sensors:* By grabbing environmental data from the sensors, retailers can implement and send data to the cloud to run analytics. For example, a retail store can grab data from a sensor to track customer behaviors. If a sensor is tracking the customers' walking patterns, the system can suggest products that the customers might be interested in. The system can also track customers from their walking patterns and send notifications based on the customer's behavior. For example, if a customer looks at a product for a long time, the system will send information about that product to the customer's mobile device. This can be a great way to increase the conversion with potential consumers.

Student can learn about data-driven farming using AI, Machine learning and IoT with with FarmBeats Raspberry Pi Kit. Source: Seeed.

Train apps to distinguish various plants. Source: Lobe.

- *Automated marketing:* You can automate your marketing communications with customers. You can create customer segments based on their interests, send them targeted messages, and run retargeting campaigns.
- *Automated customer service:* You can use NLP and speech-to-text to automate the customer service experience.
- *IT service management:* This can assist in the design, planning, delivery, operation, and control of all activities through the whole service process offered to customers. For example, with the help of Jira Service Management (see Figure 1-12), you can easily receive, track, manage, respond, and resolve customer requests. Customers can send requests via email and embedded plug-ins. Jira Service Management will systematically organize these requests in one place, and then prioritize requests to decide which to execute.

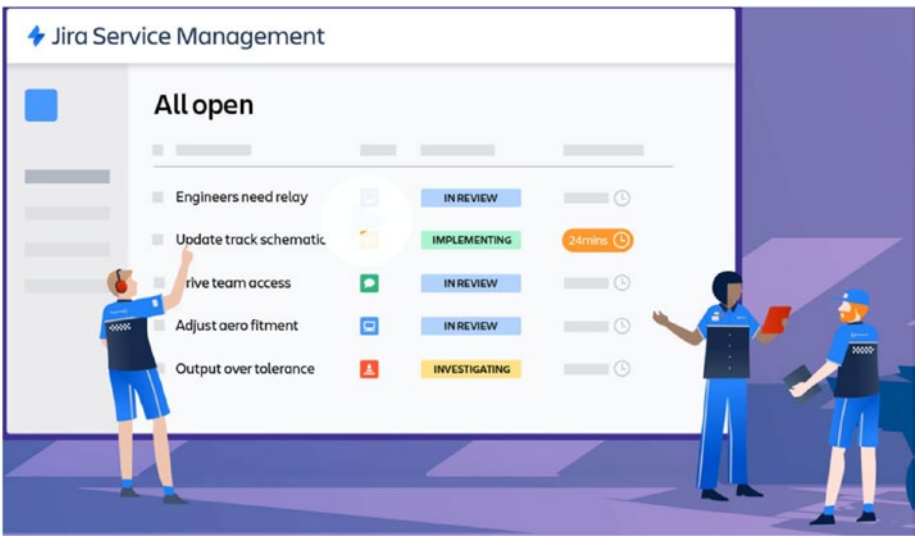

Figure 1-10. *Jira Service Management*

To Automate or Not to Automate?

Before implementing automation into your retail business, it is very important to understand the limitations of the current technologies. While some automation targets might seem lucrative and in theory could provide significant gains due to efficiency, you may discover that the modern technological stack is not sufficient to achieve your desired goals.

For example, say your customers want to talk to customer service during their online shopping process, but the chatbots automatically respond to these conversations without correctly responding to the complicated questions. In this case, your users may feel it's a waste of time when interacting with chatbots. Likewise, when we call the bank, there is often too much waiting time for automatic problem identification. When we book a hotel or travel itinerary online, we don't like to wait for a conversation with a bot agent. It often takes a lot of the customer's time to drill through the menus and get the appropriate help. Customers may hang up or disconnect with indignation. The worst result is when customers blacklist a company or service due to the poor level of service they received.

Speech recognition and computer vision applications are not yet 100% accurate when it comes to automation. In later chapters, we use real examples to show how computer vision can be effectively applied in the retail business using Raspberry Pi, so that you can take reference to your business.

> *"Conversational AI is in many ways the ultimate AI. Deep learning breakthroughs in speech recognition, language understanding, and speech synthesis have enabled engaging cloud services. NVIDIA Jarvis brings this state-of-the-art conversational AI out of the cloud for customers to host AI services anywhere."*
>
> —Jensen Huang, Founder and CEO of NVIDIA, GTC2021 keynote

When looking for automation solutions, some key points to consider are:

- What are the reasons to choose automation?
- How much time will it take to integrate automation?
- How much time will it take to adapt the automation solution to the existing processes?
- How many business units will it impact?
- How many users will it impact?
- Will automation simplify the user experience, or will it complicate it?
- Will automation be able to reduce the support costs?

Apart from picking the right target for automation, when you're trying to integrate several different technologies into the workflow, it is important also to choose the right tools and technologies and not over-engineer the project. You can always add new tools and technologies later, but you will surely regret not having the most appropriate tools and technologies right from the start.

Choosing Tools

When it comes to choosing the right tools for your project, you should never sacrifice flexibility for ease of use. The best tools are not necessarily easy to use, but they are flexible and allow you to extend their functionality without losing time. One of the most common examples of this behavior is using Python for automation, while C is the most popular programming language required for automation development. Python is very easy to learn, but it is not as fast as C, which is more complex. However, Python allows developers to write less code, which makes it more flexible. Also, when your project uses open-source technologies, you can easily find developers with the necessary skills to extend your solution's functionality.