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(54) **SYSTEMS AND METHODS FOR MEASURING TRAFFIC DENSITY IN A REGION**

(71) Applicant: **SHOPIFY INC.**, Ottawa (CA)

(72) Inventor: **BRENT MARSHALL**, KITCHENER (CA)

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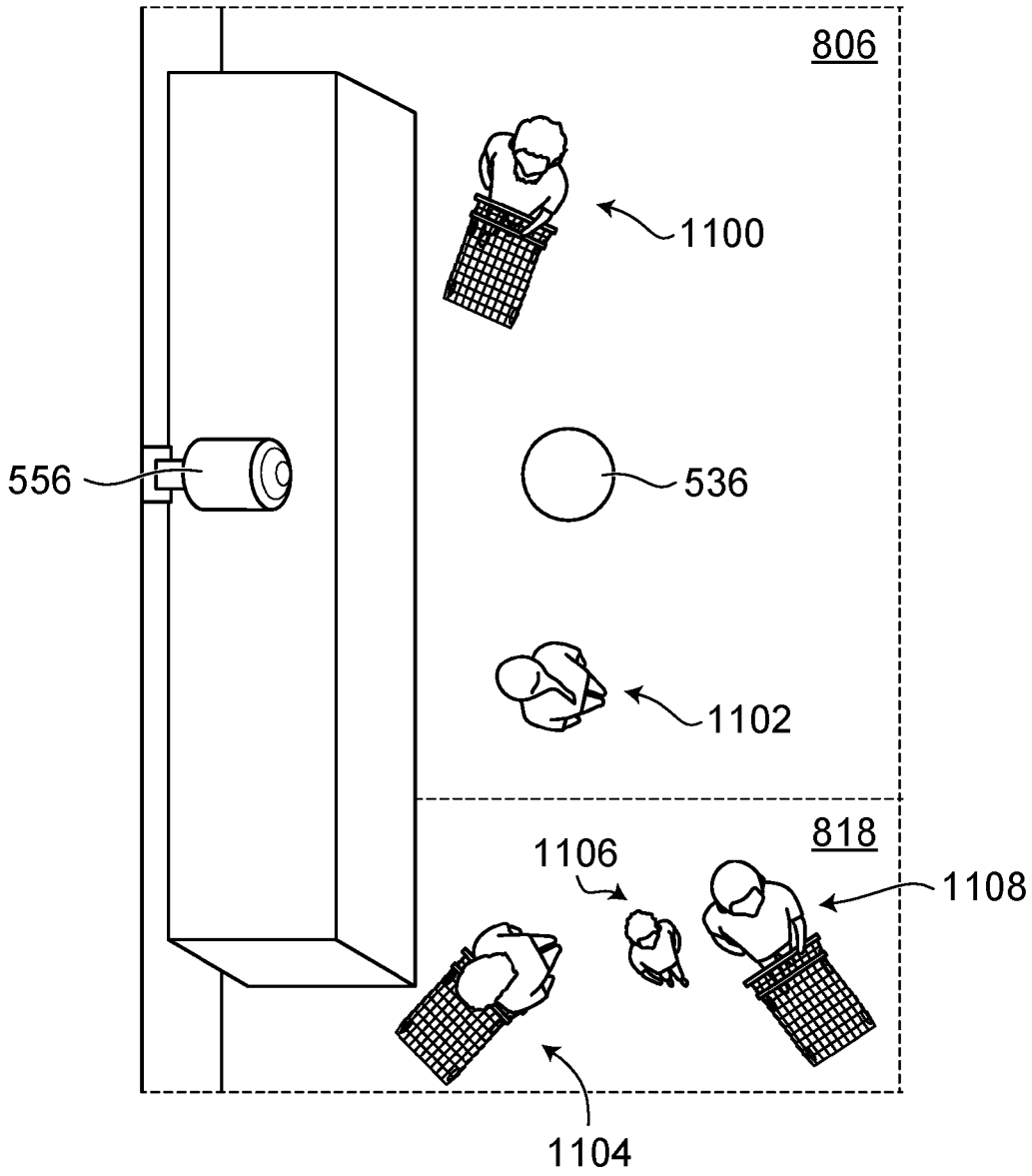
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CPC ***G06Q 30/0201*** (2013.01); ***G06Q 10/0637*** (2013.01); ***G01S 13/04*** (2013.01)

(57) **ABSTRACT**

Computer-implemented systems and methods for determining the value of display space in a retail store are provided. These values of display space are determined based on measured traffic densities in the retail store. Traffic density is used as a metric for real-world customer activity and customer patterns in the retail store. To determine traffic density, measurements are obtained from one or more sensors in the retail store, where the measurements include spatial information pertaining to a region of the retail store. Traffic density can provide a quantitative, accurate and unbiased metric with which to determine a value associated with displaying products in a region of the retail store.



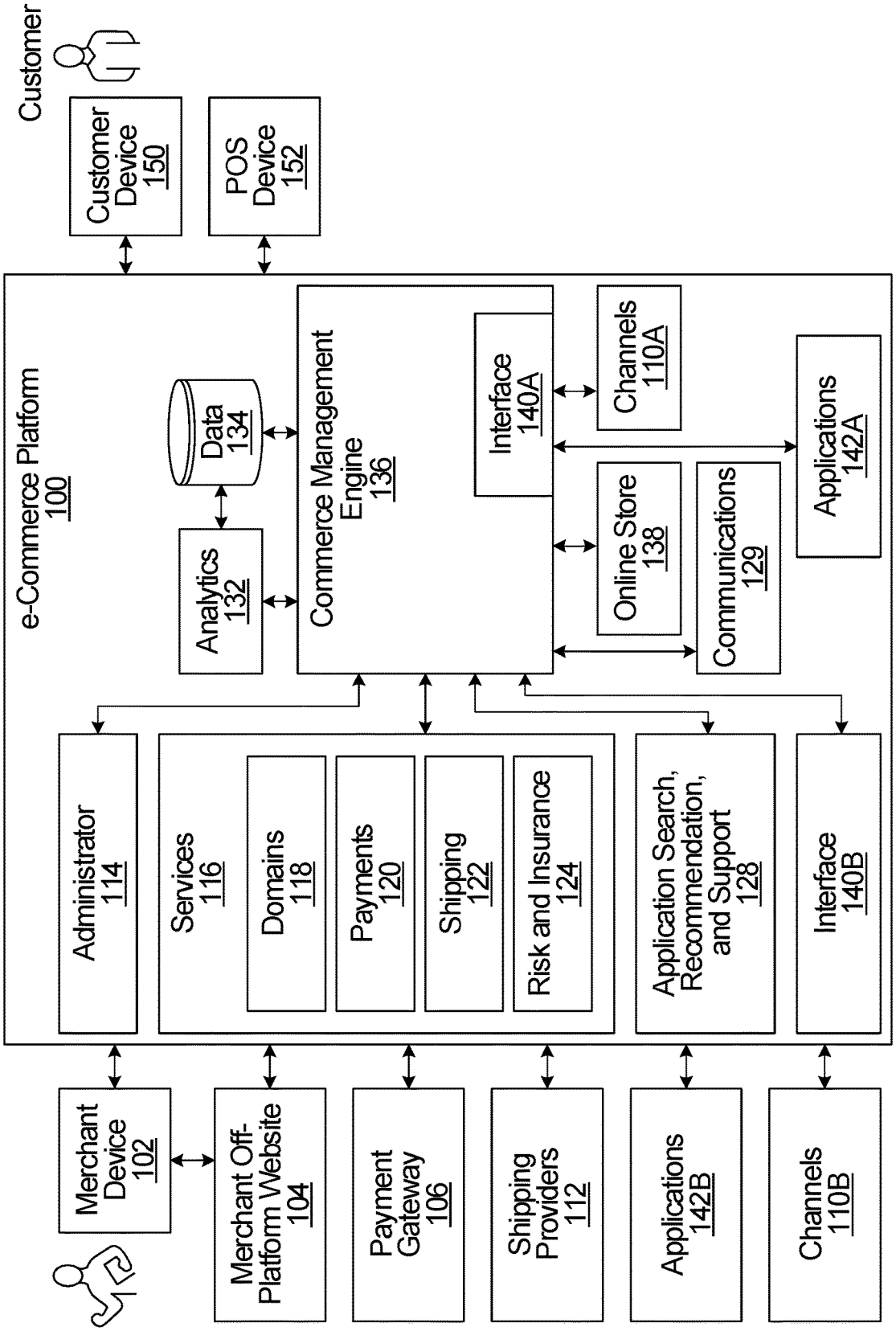

Customer
Customer Device 150
POS Device 152
e-Commerce Platform 100
Data 134
Commerce Management Engine 136
Interface 140A
Channels 110A
Analytics 132
Online Store 138
Communications 129
Applications 142A
Administrator 114
Services 116
Domains 118
Payments 120
Shipping 122
Risk and Insurance 124
Application Search, Recommendation, and Support 128
Interface 140B
Merchant Device 102
Merchant Off-Platform Website 104
Payment Gateway 106
Shipping Providers 112
Applications 142B
Channels 110B

FIG. 1


E-Commerce Platform
Search
JG
John's Apparel
Jonny B. Good
Home
Orders
Products
Customers
Reports
Discounts
Apps
SALES CHANNELS
Online Store
Mobile App
View all channels
Settings
Good afternoon, Jonny B..
Here's what's happening with your store today.
Today's total sales
$98.00
Today's visits
1
Update your Platform Payments tax details
We require additional information to verify your identity.
Update tax details
Advanced Cash on Delivery has been deactivated for your store
See why
All channels
Today
TOTAL SALES
Jun 1
$98.00
2 orders
$125
$75
$25
12am
8pm
4pm
11pm
TOTAL SALES BY CHANNEL
Jun 1
Online Store
View dashboard
$0.00
0 orders
Mobile app
$0.00
0 orders
Shopify POS (126 York St.)
$0.00
0 orders

FIG. 2

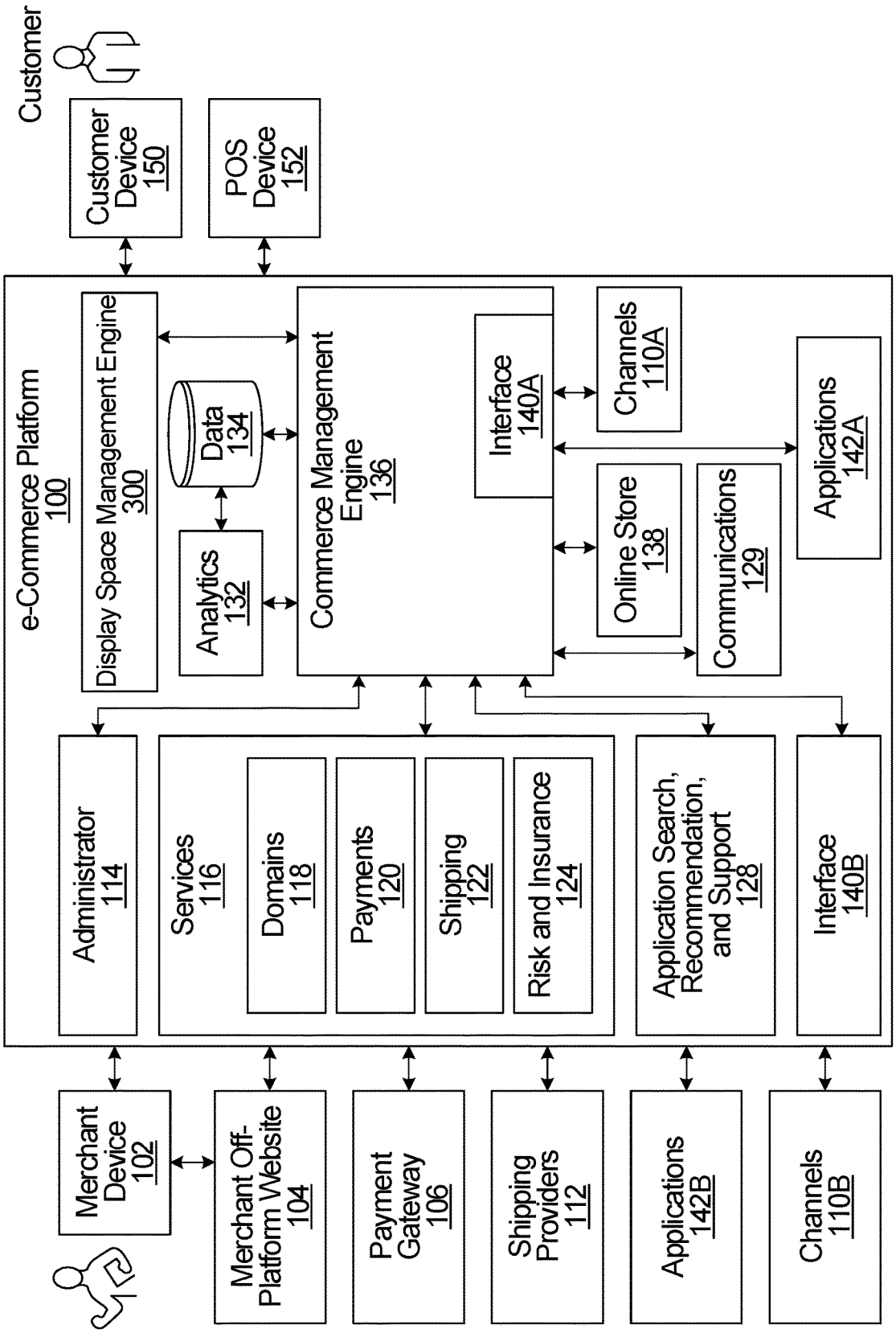

Customer
Customer Device 150
POS Device 152
e-Commerce Platform 100
Display Space Management Engine 300
Data 134
Analytics 132
Commerce Management Engine 136
Interface 140A
Channels 110A
Online Store 138
Communications 129
Applications 142A
Administrator 114
Services 116
Domains 118
Payments 120
Shipping 122
Risk and Insurance 124
Application Search, Recommendation, and Support 128
Interface 140B
Merchant Device 102
Merchant Off-Platform Website 104
Payment Gateway 106
Shipping Providers 112
Applications 142B
Channels 110B

FIG. 3

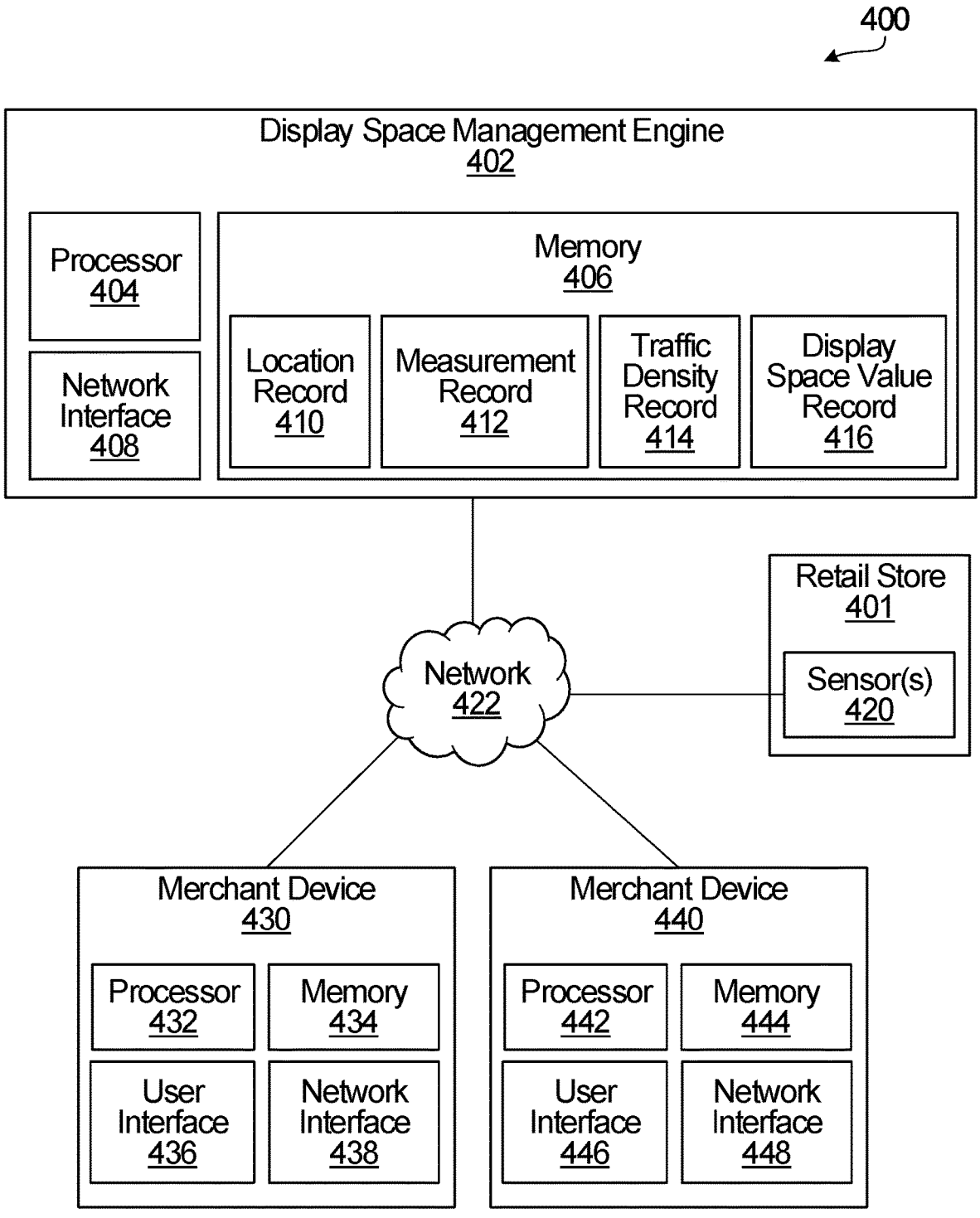

400
Display Space Management Engine
402
Processor
404
Network Interface
408
Memory
406
Location Record
410
Measurement Record
412
Traffic Density Record
414
Display Space Value Record
416
Network
422
Retail Store
401
Sensor(s)
420
Merchant Device
430
Processor
432
Memory
434
User Interface
436
Network Interface
438
Merchant Device
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Processor
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Memory
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User Interface
446
Network Interface
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FIG. 4

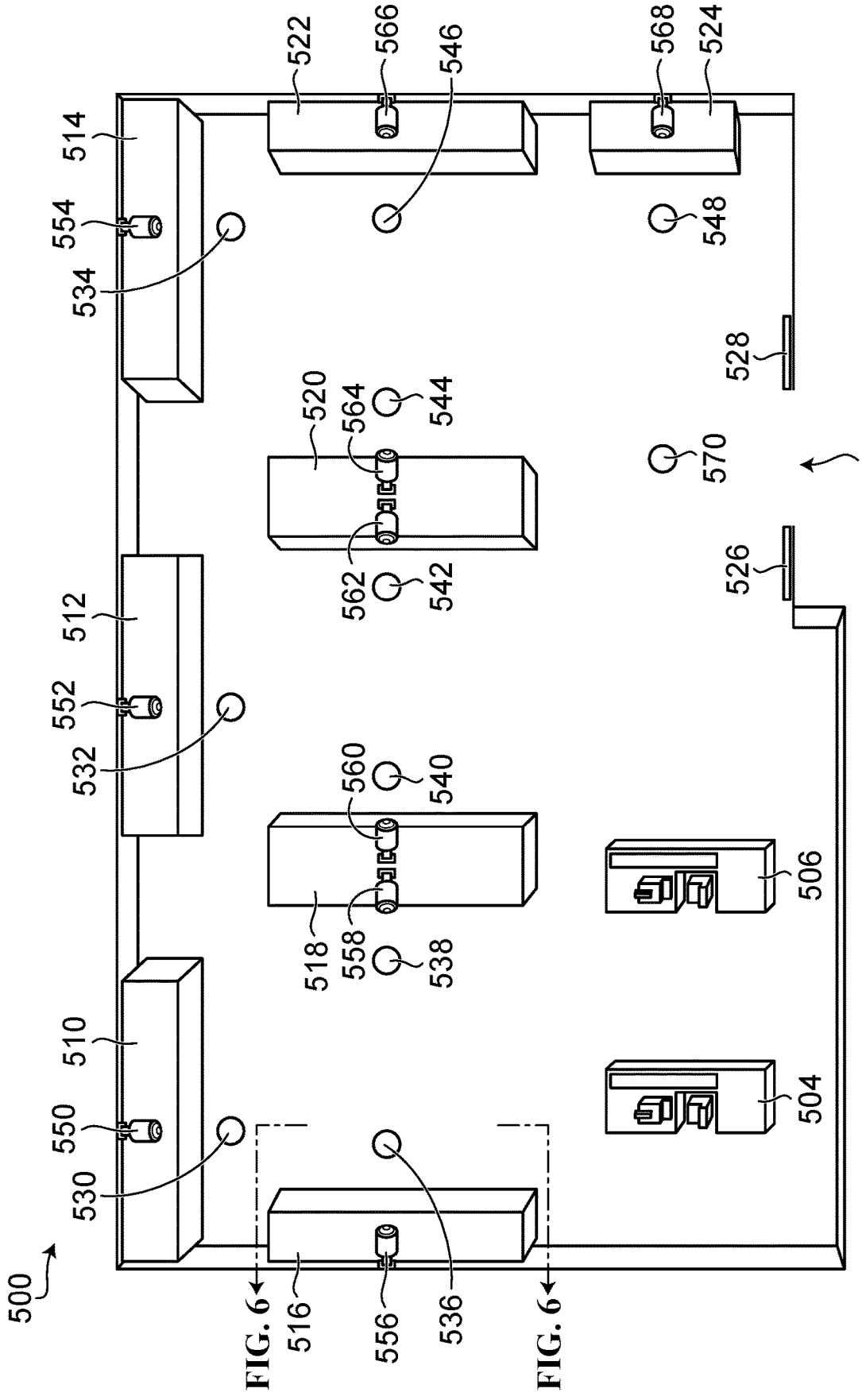

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FIG. 6
FIG. 6

FIG. 5

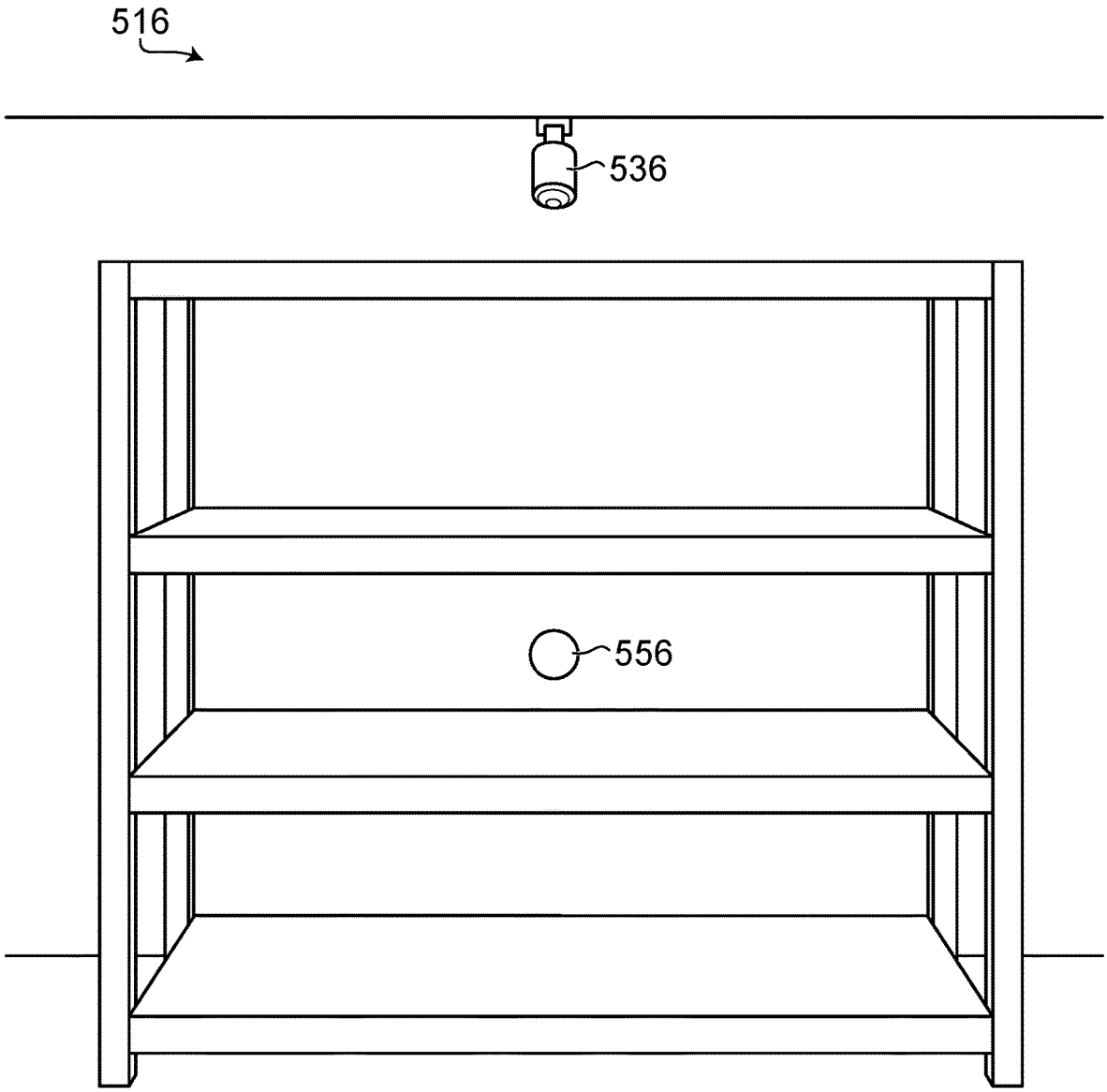


FIG. 6

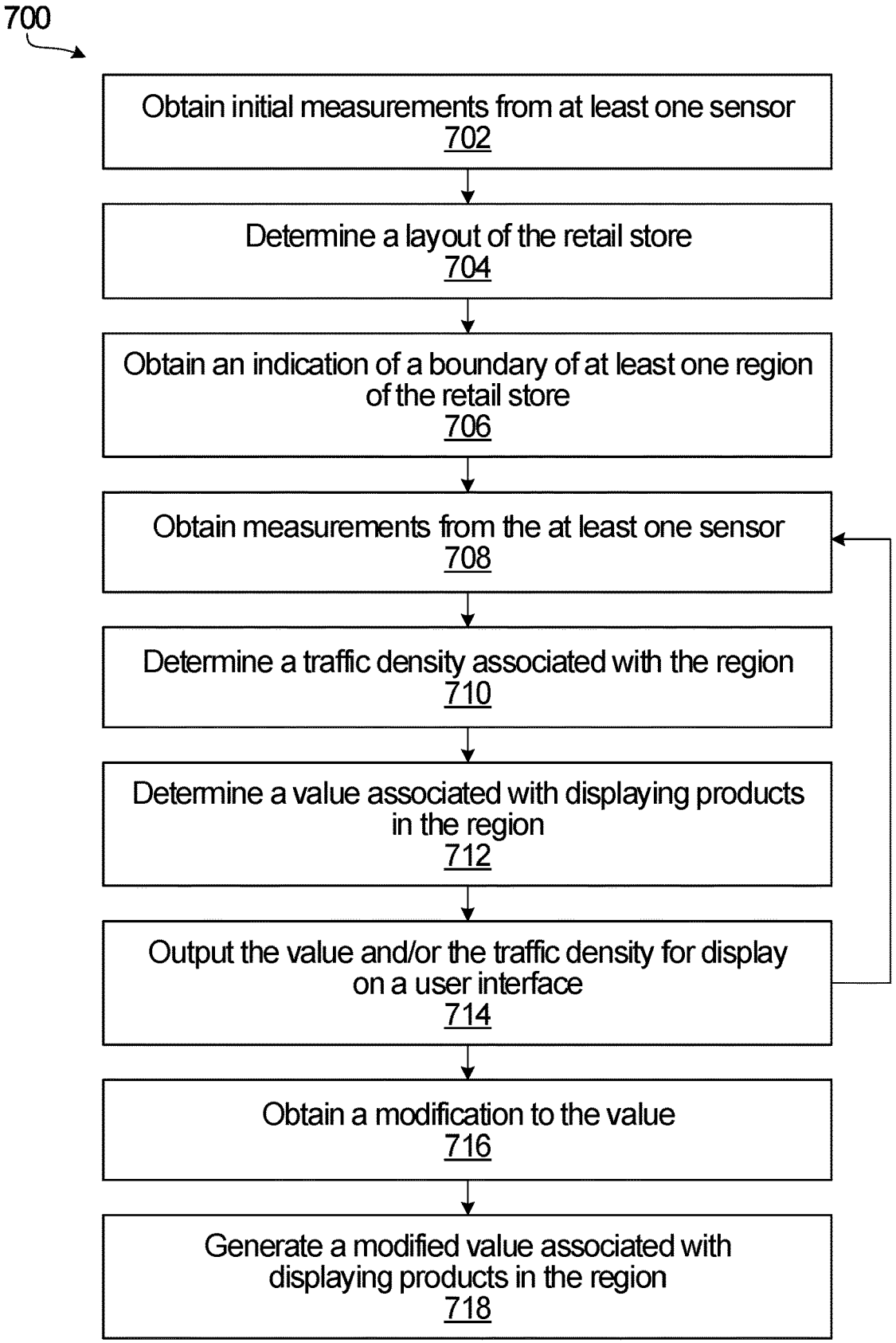

700
Obtain initial measurements from at least one sensor
702
Determine a layout of the retail store
704
Obtain an indication of a boundary of at least one region of the retail store
706
Obtain measurements from the at least one sensor
708
Determine a traffic density associated with the region
710
Determine a value associated with displaying products in the region
712
Output the value and/or the traffic density for display on a user interface
714
Obtain a modification to the value
716
Generate a modified value associated with displaying products in the region
718

FIG. 7

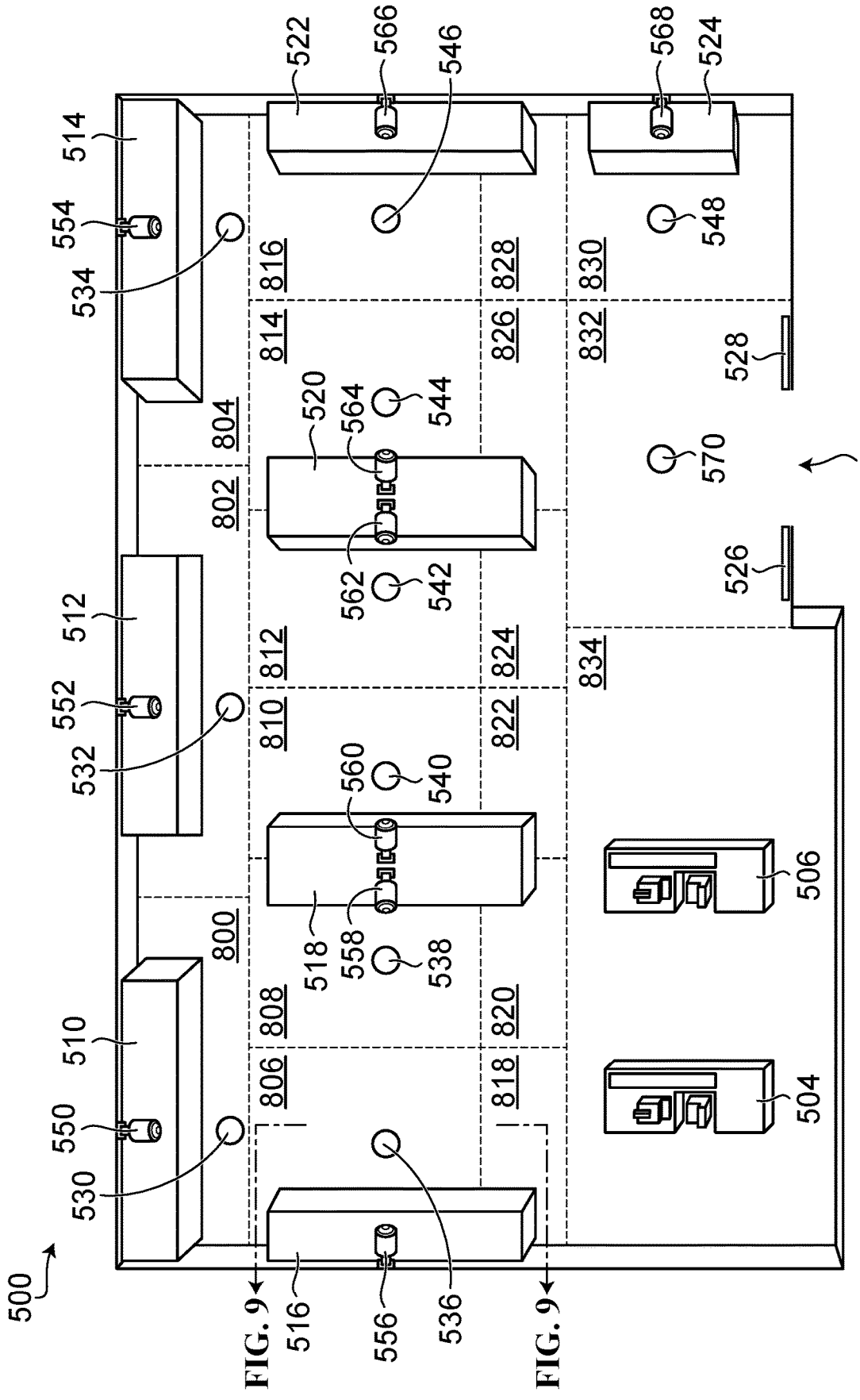

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FIG. 9
FIG. 9

FIG. 8

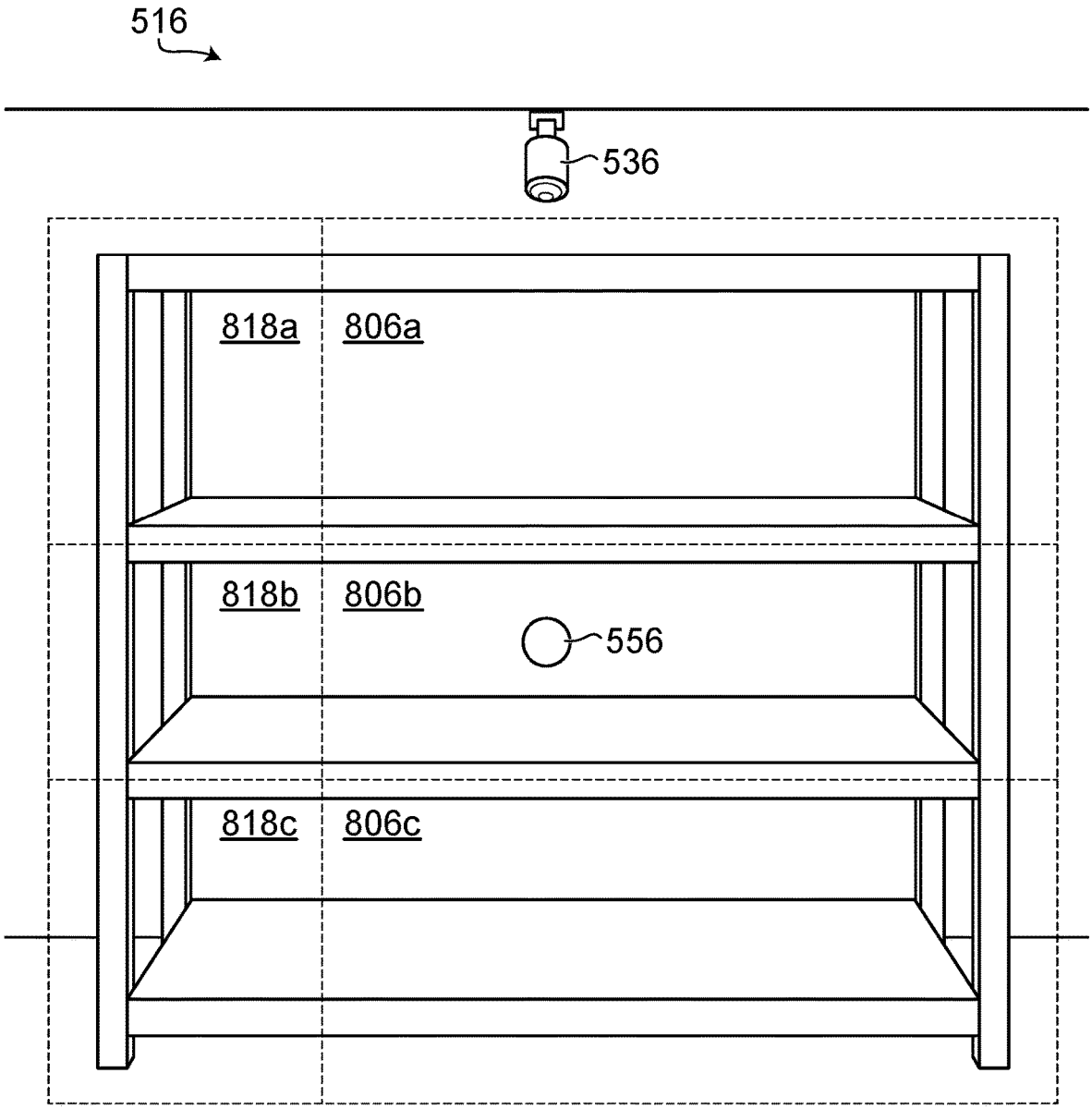


FIG. 9

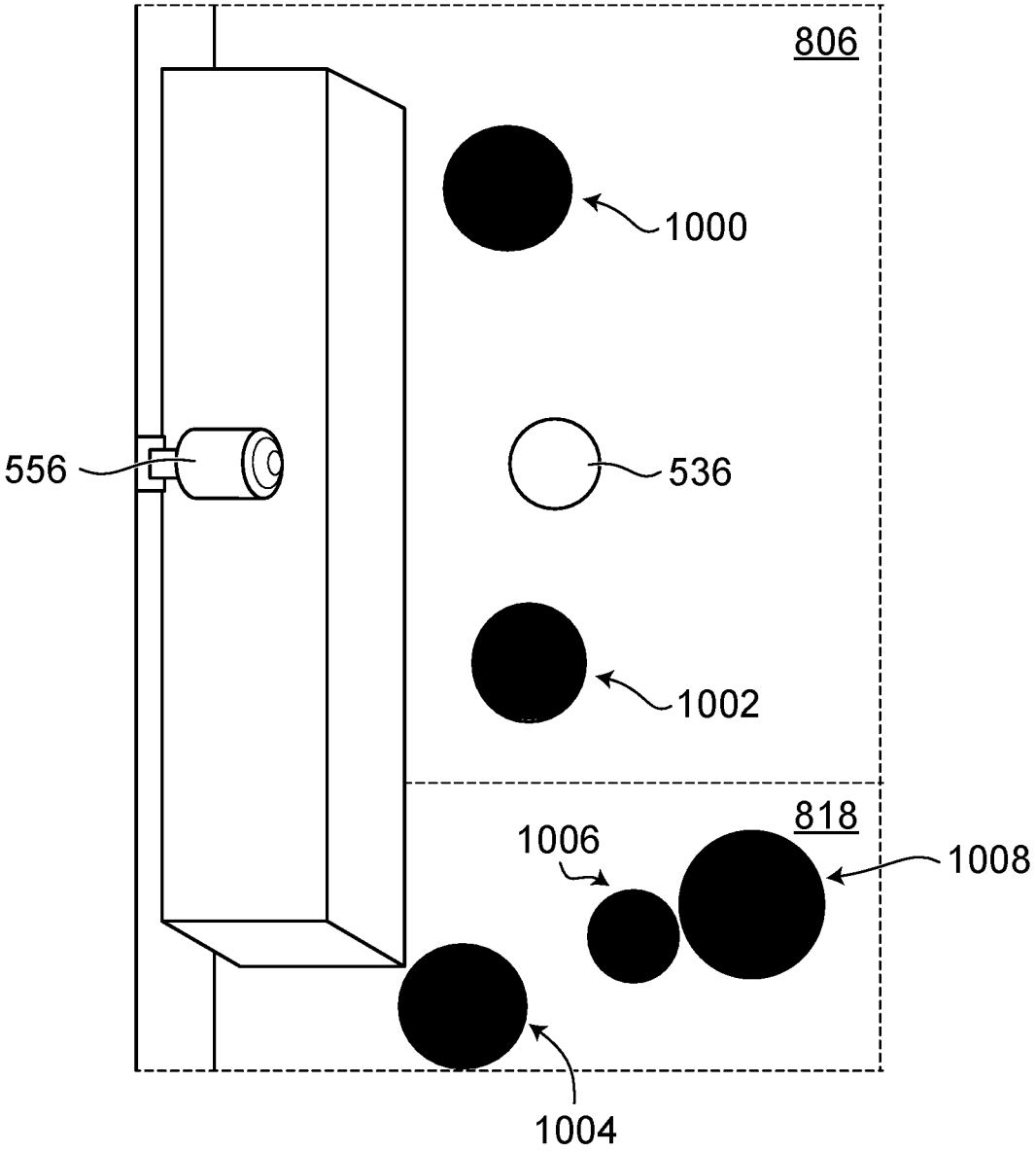


FIG. 10

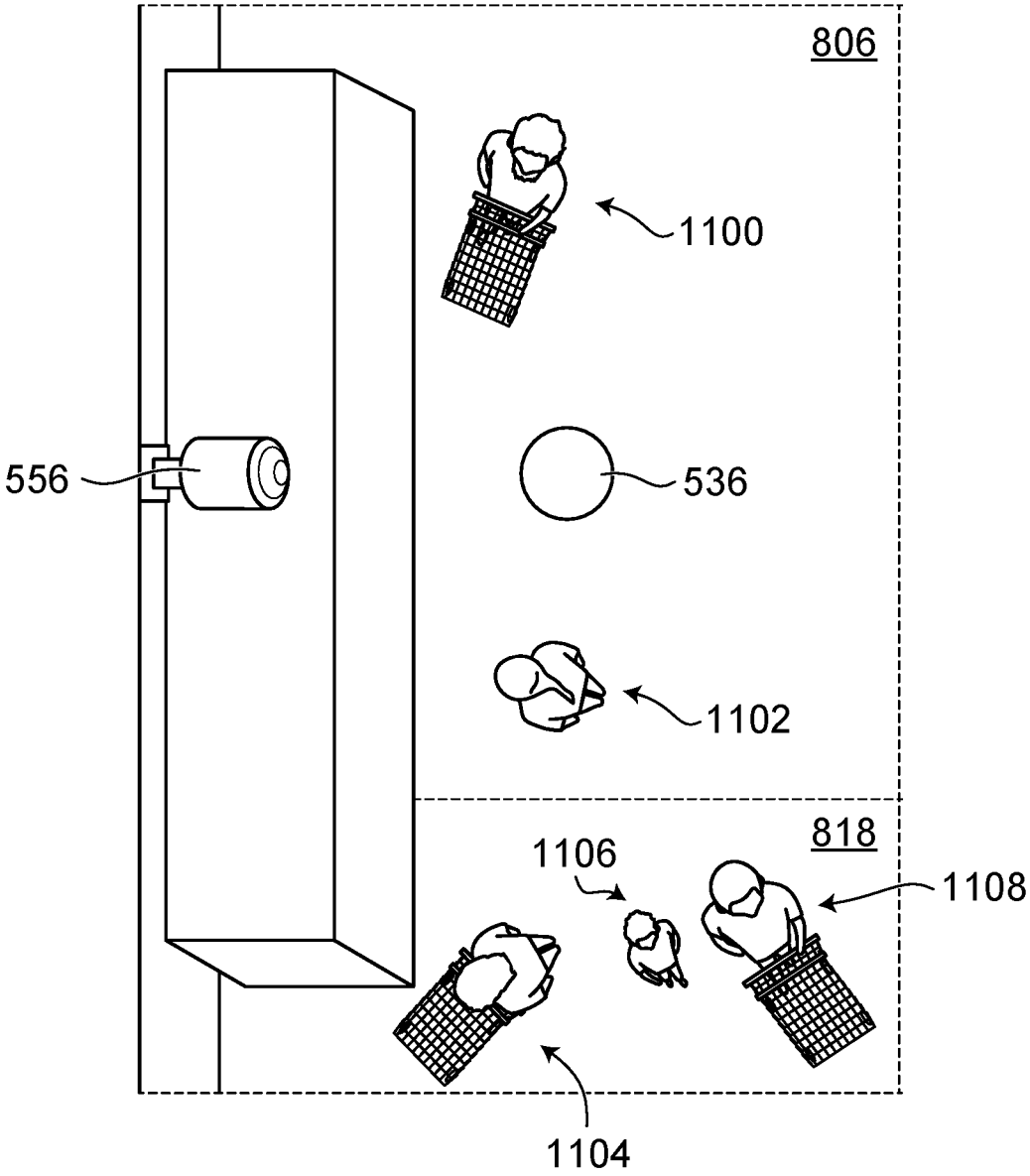


FIG. 11

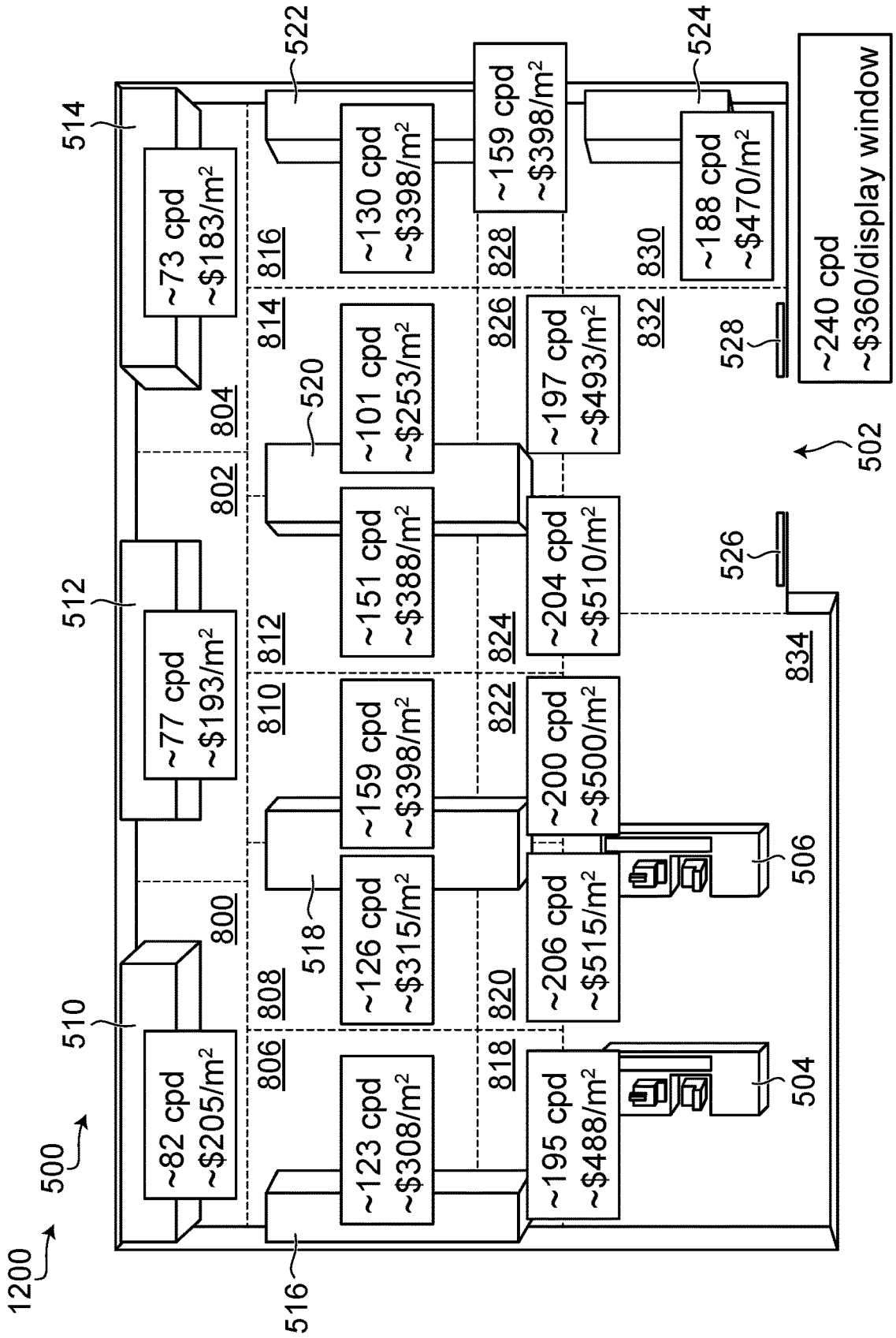

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~82 cpd ~$205/m²
~73 cpd ~$183/m²
~77 cpd ~$193/m²
~126 cpd ~$315/m²
~151 cpd ~$388/m²
~159 cpd ~$398/m²
~123 cpd ~$308/m²
~101 cpd ~$253/m²
~130 cpd ~$398/m²
~206 cpd ~$515/m²
~204 cpd ~$510/m²
~200 cpd ~$500/m²
~195 cpd ~$488/m²
~197 cpd ~$493/m²
~159 cpd ~$398/m²
~188 cpd ~$470/m²
~240 cpd ~$360/display window

FIG. 12

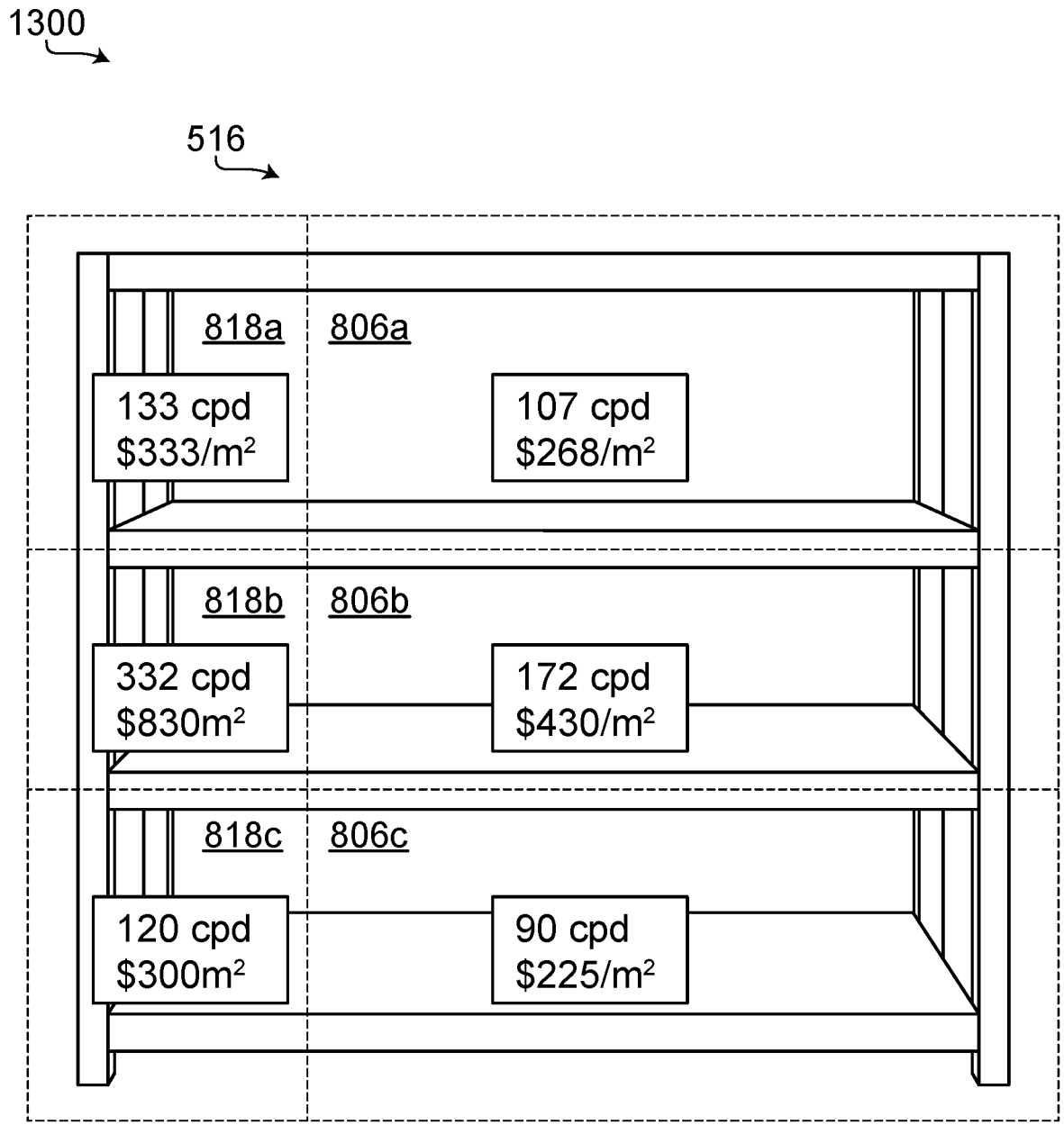

1300
516
818a
806a
133 cpd
$333/m²
107 cpd
$268/m²
818b
806b
332 cpd
$830m²
172 cpd
$430/m²
818c
806c
120 cpd
$300m²
90 cpd
$225/m²

FIG. 13

SYSTEMS AND METHODS FOR MEASURING TRAFFIC DENSITY IN A REGION

FIELD

[0001] The present application relates generally to measurement of traffic densities, and in particular embodiments, to measuring the traffic density of a region.

BACKGROUND

[0002] Some commercial locations include display space that is sold (or leased) to other individuals or entities. Retail stores are an example of this. An owner of a retail store may sell some or all of the display space within the store to a merchant that can then use the display space to advertise and/or sell their products. In some cases, the display space may include shelf space where physical products can be displayed to customers. The merchant can benefit from any sales of the products that occur through the retail store.

SUMMARY

[0003] From the perspective of a merchant that is interested in purchasing (or leasing) display space in a retail store, not all regions of the retail store are equally desirable. As such, the value of display space in different regions of a retail store is generally not fixed. Determining the value of display space in a manner that is reliable, accurate and unbiased remains a challenge. Indeed, the value of display space in a region of a location, such as a region of a retail store, is difficult to quantize. In some embodiments of the present disclosure, the value of display space in a region of a retail store is determined based on a measured quantity of traffic in the region, which is also referred to herein as a "traffic density". The traffic density is determined based on a series of measurements that are obtained by one or more sensors. The measurements include spatial information that may indicate the presence of customers and/or shopping carts in the region, for example. The actions of customers in the region, such as the amount of time they spend in the region and the number of interactions with products that they have in the region, can also or instead be derived from the measurements. Advantageously, traffic density can provide a quantitative, accurate and unbiased metric with which to determine a value associated with displaying products in a region.

[0004] According to one aspect of the present disclosure, a computer-implemented method is provided. The method includes obtaining measurements from at least one sensor, where the measurements include spatial information pertaining to a region of a retail store. In some embodiments, the spatial information includes at least one of a position, a shape and a speed of an entity in the region. The spatial information may also include three-dimensional information. Based on the measurements, a traffic density associated with the region is determined. The method further includes determining, based on the traffic density, a value associated with displaying products in the region.

[0005] This method can be performed for multiple regions in the retail store. Accordingly, in some embodiments, the region is a first region, the traffic density is a first traffic density and the value is a first value. The measurements can include spatial information pertaining to a plurality of regions of the retail store, the plurality of regions including the first region and a second region. Further, the computer-implemented method includes determining, based on the measurements, a second traffic density associated with the second region. The first value can be determined by comparing the first traffic density to the second traffic density. The method can also include determining, based on the second traffic density, a second value associated with displaying products in the second region.

[0006] In some embodiments, determining the traffic density can include at least one of: determining a number of persons that enter the region over a period of time; determining an average time that a person spends in the region; determining a number of shopping carts that enter the region over the period of time; and determining a number of persons that interact with products in the region over the period of time.

[0007] The at least one sensor may be adjustable to achieve various different capabilities. In some embodiments, obtaining the measurements from the at least one sensor includes: obtaining, from the at least one sensor, a first measurement of an entity that is in the region; adjusting the at least one sensor based on the first measurement; and after adjusting the at least one sensor, obtaining a second measurement of the entity. Adjusting the at least one sensor can include adjusting a resolution of the at least one sensor.

[0008] In some embodiments, prior to obtaining the measurements, the method includes obtaining initial measurements from the at least one sensor when no persons are present in the region of the retail store, the initial measurements including initial spatial information pertaining to fixed structures within the region. This can be considered an initial calibration step for the at least one sensor in the retail store. Determining the traffic density associated with the region may then be based on the initial measurements.

[0009] In some embodiments, obtaining the measurements includes obtaining radio wave measurements. For example, the at least one sensor may be a radar sensor.

[0010] In some embodiments, the method further includes outputting the value and/or the traffic density for display on a user interface with a representation of the region of the retail store. This can allow a user to view the value and/or the traffic density.

[0011] In some embodiments, the method further includes obtaining, from a user interface, a modification to the value. Based on the modification, a modified value associated with displaying products in the region can be generated. This allows users to adjust the values of display space in the retail store.

[0012] The regions of the retail store may be user selected. As such, in some embodiments, the method further includes obtaining, from a user interface, an indication of a boundary of the region of the retail store.

[0013] According to another aspect of the present disclosure, there is provided a system including a memory to store measurements, and one or more processors to perform any method as disclosed herein.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] Embodiments will be described, by way of example only, with reference to the accompanying figures wherein:

[0015] FIG. **1** is a block diagram of an e-commerce platform, according to one embodiment;

[0016] FIG. **2** is an example of a home page of an administrator, according to one embodiment;

[0017] FIG. **3** illustrates the e-commerce platform of FIG. **1**, but including a display space management engine;

[0018] FIG. **4** is a block diagram illustrating a system for determining traffic densities and evaluating display space for a retail store, according to one embodiment;

[0019] FIG. **5** illustrates a layout of a retail store, according to one embodiment;

[0020] FIG. **6** is a side-view of a shelving unit shown in FIG. **5**;

[0021] FIG. **7** is a flow diagram illustrating a method for evaluating display space, according to one embodiment;

[0022] FIG. **8** illustrates a layout of the retail store shown in FIG. **5**, with multiple different regions delineated by dashed lines;

[0023] FIG. **9** is a side-view of the shelving unit shown in FIG. **6** and two of the regions shown in FIG. **8**;

[0024] FIG. **10** illustrates a first set of spatial data point clusters in two of the regions shown in FIG. **8**;

[0025] FIG. **11** illustrates a second set of spatial data point clusters in two of the regions shown in FIG. **8**;

[0026] FIG. **12** illustrates content showing traffic densities and values of display space overlaid with the layout of the retail store shown in FIG. **5**; and

[0027] FIG. **13** illustrates content showing traffic densities and values of display space overlaid with the shelving unit shown in FIG. **6**.

DETAILED DESCRIPTION

[0028] For illustrative purposes, specific example embodiments will now be explained in greater detail below in conjunction with the figures.

Example e-Commerce Platform

[0029] In some embodiments, the methods disclosed herein may be performed on or in association with a commerce platform, which will be referred to herein as an e-commerce platform. Therefore, an example of an e-commerce platform will be described.

[0030] FIG. **1** illustrates an e-commerce platform **100**, according to one embodiment. The e-commerce platform **100** may be used to provide merchant products and services to customers. While the disclosure contemplates using the apparatus, system, and process to purchase products and services, for simplicity the description herein will refer to products. All references to products throughout this disclosure should also be understood to be references to products and/or services, including physical products, digital content, tickets, subscriptions, services to be provided, and the like.

[0031] While the disclosure throughout contemplates that a 'merchant' and a 'customer' may be more than individuals, for simplicity the description herein may generally refer to merchants and customers as such. All references to merchants and customers throughout this disclosure should also be understood to be references to groups of individuals, companies, corporations, computing entities, and the like, and may represent for-profit or not-for-profit exchange of products. Further, while the disclosure throughout refers to 'merchants' and 'customers', and describes their roles as such, the e-commerce platform **100** should be understood to more generally support users in an e-commerce environment, and all references to merchants and customers throughout this disclosure should also be understood to be references to users, such as where a user is a merchant-user (e.g., a seller, retailer, wholesaler, or provider of products), a customer-user (e.g., a buyer, purchase agent, or user of products), a prospective user (e.g., a user browsing and not yet committed to a purchase, a user evaluating the e-commerce platform **100** for potential use in marketing and selling products, and the like), a service provider user (e.g., a shipping provider **112**, a financial provider, and the like), a company or corporate user (e.g., a company representative for purchase, sales, or use of products; an enterprise user; a customer relations or customer management agent, and the like), an information technology user, a computing entity user (e.g., a computing bot for purchase, sales, or use of products), and the like.

[0032] The e-commerce platform **100** may provide a centralized system for providing merchants with online resources and facilities for managing their business. The facilities described herein may be deployed in part or in whole through a machine that executes computer software, modules, program codes, and/or instructions on one or more processors which may be part of or external to the platform **100**. Merchants may utilize the e-commerce platform **100** for managing commerce with customers, such as by implementing an e-commerce experience with customers through an online store **138**, through channels **110**A-B, through POS devices **152** in physical locations (e.g., a physical storefront or other location such as through a kiosk, terminal, reader, printer, 3D printer, and the like), by managing their business through the e-commerce platform **100**, and by interacting with customers through a communications facility **129** of the e-commerce platform **100**, or any combination thereof. A merchant may utilize the e-commerce platform **100** as a sole commerce presence with customers, or in conjunction with other merchant commerce facilities, such as through a physical store (e.g., 'brick-and-mortar' retail stores), a merchant off-platform website **104** (e.g., a commerce Internet website or other internet or web property or asset supported by or on behalf of the merchant separately from the e-commerce platform), and the like. However, even these 'other' merchant commerce facilities may be incorporated into the e-commerce platform, such as where POS devices **152** in a physical store of a merchant are linked into the e-commerce platform **100**, where a merchant off-platform website **104** is tied into the e-commerce platform **100**, such as through 'buy buttons' that link content from the merchant off platform website **104** to the online store **138**, and the like.

[0033] The online store **138** may represent a multitenant facility comprising a plurality of virtual storefronts. In embodiments, merchants may manage one or more storefronts in the online store **138**, such as through a merchant device **102** (e.g., computer, laptop computer, mobile computing device, and the like), and offer products to customers through a number of different channels **110**A-B (e.g., an online store **138**; a physical storefront through a POS device **152**; electronic marketplace, through an electronic buy button integrated into a website or social media channel such as on a social network, social media page, social media messaging system; and the like). A merchant may sell across channels **110**A-B and then manage their sales through the e-commerce platform **100**, where channels **110**A may be provided internal to the e-commerce platform **100** or from outside the e-commerce channel **110**B. A merchant may sell in their physical retail store, at pop ups, through wholesale, over the phone, and the like, and then manage their sales through the e-commerce platform **100**. A merchant may

employ all or any combination of these, such as maintaining a business through a physical storefront utilizing POS devices **152**, maintaining a virtual storefront through the online store **138**, and utilizing a communication facility **129** to leverage customer interactions and analytics **132** to improve the probability of sales. Throughout this disclosure the terms online store **138** and storefront may be used synonymously to refer to a merchant's online e-commerce offering presence through the e-commerce platform **100**, where an online store **138** may refer to the multitenant collection of storefronts supported by the e-commerce platform **100** (e.g., for a plurality of merchants) or to an individual merchant's storefront (e.g., a merchant's online store).

[0034] In some embodiments, a customer may interact through a customer device **150** (e.g., computer, laptop computer, mobile computing device, and the like), a POS device **152** (e.g., retail device, a kiosk, an automated checkout system, and the like), or any other commerce interface device known in the art. The e-commerce platform **100** may enable merchants to reach customers through the online store **138**, through POS devices **152** in physical locations (e.g., a merchant's storefront or elsewhere), to promote commerce with customers through dialog via electronic communication facility **129**, and the like, providing a system for reaching customers and facilitating merchant services for the real or virtual pathways available for reaching and interacting with customers.

[0035] In some embodiments, and as described further herein, the e-commerce platform **100** may be implemented through a processing facility including a processor and a memory, the processing facility storing a set of instructions that, when executed, cause the e-commerce platform **100** to perform the e-commerce and support functions as described herein. The processing facility may be part of a server, client, network infrastructure, mobile computing platform, cloud computing platform, stationary computing platform, or other computing platform, and provide electronic connectivity and communications between and amongst the electronic components of the e-commerce platform **100**, merchant devices **102**, payment gateways **106**, application developers, channels **110**A-B, shipping providers **112**, customer devices **150**, point of sale devices **152**, and the like. The e-commerce platform **100** may be implemented as a cloud computing service, a software as a service (SaaS), infrastructure as a service (IaaS), platform as a service (PaaS), desktop as a Service (DaaS), managed software as a service (MSaaS), mobile backend as a service (MBaaS), information technology management as a service (ITMaaS), and the like, such as in a software and delivery model in which software is licensed on a subscription basis and centrally hosted (e.g., accessed by users using a client (for example, a thin client) via a web browser or other application, accessed through by POS devices, and the like). In some embodiments, elements of the e-commerce platform **100** may be implemented to operate on various platforms and operating systems, such as iOS, Android, on the web, and the like (e.g., the administrator **114** being implemented in multiple instances for a given online store for iOS, Android, and for the web, each with similar functionality).

[0036] In some embodiments, the online store **138** may be served to a customer device **150** through a webpage provided by a server of the e-commerce platform **100**. The server may receive a request for the webpage from a browser or other application installed on the customer device **150**, where the browser (or other application) connects to the server through an IP Address, the IP address obtained by translating a domain name. In return, the server sends back the requested webpage. Webpages may be written in or include Hypertext Markup Language (HTML), template language, JavaScript, and the like, or any combination thereof. For instance, HTML is a computer language that describes static information for the webpage, such as the layout, format, and content of the webpage. Website designers and developers may use the template language to build webpages that combine static content, which is the same on multiple pages, and dynamic content, which changes from one page to the next. A template language may make it possible to re-use the static elements that define the layout of a webpage, while dynamically populating the page with data from an online store. The static elements may be written in HTML, and the dynamic elements written in the template language. The template language elements in a file may act as placeholders, such that the code in the file is compiled and sent to the customer device **150** and then the template language is replaced by data from the online store **138**, such as when a theme is installed. The template and themes may consider tags, objects, and filters. The client device web browser (or other application) then renders the page accordingly.

[0037] In some embodiments, online stores **138** may be served by the e-commerce platform **100** to customers, where customers can browse and purchase the various products available (e.g., add them to a cart, purchase immediately through a buy-button, and the like). Online stores **138** may be served to customers in a transparent fashion without customers necessarily being aware that it is being provided through the e-commerce platform **100** (rather than directly from the merchant). Merchants may use a merchant configurable domain name, a customizable HTML theme, and the like, to customize their online store **138**. Merchants may customize the look and feel of their website through a theme system, such as where merchants can select and change the look and feel of their online store **138** by changing their theme while having the same underlying product and business data shown within the online store's product hierarchy. Themes may be further customized through a theme editor, a design interface that enables users to customize their website's design with flexibility. Themes may also be customized using theme-specific settings that change aspects, such as specific colors, fonts, and pre-built layout schemes. The online store may implement a content management system for website content. Merchants may author blog posts or static pages and publish them to their online store **138**, such as through blogs, articles, and the like, as well as configure navigation menus. Merchants may upload images (e.g., for products), video, content, data, and the like to the e-commerce platform **100**, such as for storage by the system (e.g. as data **134**). In some embodiments, the e-commerce platform **100** may provide functions for resizing images, associating an image with a product, adding and associating text with an image, adding an image for a new product variant, protecting images, and the like.

[0038] As described herein, the e-commerce platform **100** may provide merchants with transactional facilities for products through a number of different channels **110**A-B, including the online store **138**, over the telephone, as well as through physical POS devices **152** as described herein. The

e-commerce platform **100** may include business support services **116**, an administrator **114**, and the like associated with running an on-line business, such as providing a domain service **118** associated with their online store, payment services **120** for facilitating transactions with a customer, shipping services **122** for providing customer shipping options for purchased products, risk and insurance services **124** associated with product protection and liability, merchant billing, and the like. Services **116** may be provided via the e-commerce platform **100** or in association with external facilities, such as through a payment gateway **106** for payment processing, shipping providers **112** for expediting the shipment of products, and the like.

[0039] In some embodiments, the e-commerce platform **100** may provide for integrated shipping services **122** (e.g., through an e-commerce platform shipping facility or through a third-party shipping carrier), such as providing merchants with real-time updates, tracking, automatic rate calculation, bulk order preparation, label printing, and the like.

[0040] FIG. **2** depicts a non-limiting embodiment for a home page of an administrator **114**, which may show information about daily tasks, a store's recent activity, and the next steps a merchant can take to build their business. In some embodiments, a merchant may log in to administrator **114** via a merchant device **102** such as from a desktop computer or mobile device, and manage aspects of their online store **138**, such as viewing the online store's **138** recent activity, updating the online store's **138** catalog, managing orders, recent visits activity, total orders activity, and the like. In some embodiments, the merchant may be able to access the different sections of administrator **114** by using the sidebar, such as shown on FIG. **2**. Sections of the administrator **114** may include various interfaces for accessing and managing core aspects of a merchant's business, including orders, products, customers, available reports and discounts. The administrator **114** may also include interfaces for managing sales channels for a store including the online store, mobile application(s) made available to customers for accessing the store (Mobile App), POS devices, and/or a buy button. The administrator **114** may also include interfaces for managing applications (Apps) installed on the merchant's account; settings applied to a merchant's online store **138** and account. A merchant may use a search bar to find products, pages, or other information. Depending on the device **102** or software application the merchant is using, they may be enabled for different functionality through the administrator **114**. For instance, if a merchant logs in to the administrator **114** from a browser, they may be able to manage all aspects of their online store **138**. If the merchant logs in from their mobile device (e.g. via a mobile application), they may be able to view all or a subset of the aspects of their online store **138**, such as viewing the online store's **138** recent activity, updating the online store's **138** catalog, managing orders, and the like.

[0041] More detailed information about commerce and visitors to a merchant's online store **138** may be viewed through acquisition reports or metrics, such as displaying a sales summary for the merchant's overall business, specific sales and engagement data for active sales channels, and the like. Reports may include, acquisition reports, behavior reports, customer reports, finance reports, marketing reports, sales reports, custom reports, and the like. The merchant may be able to view sales data for different channels **110**A-B from different periods of time (e.g., days, weeks, months, and the like), such as by using drop-down menus. An overview dashboard may be provided for a merchant that wants a more detailed view of the store's sales and engagement data. An activity feed in the home metrics section may be provided to illustrate an overview of the activity on the merchant's account. For example, by clicking on a 'view all recent activity' dashboard button, the merchant may be able to see a longer feed of recent activity on their account. A home page may show notifications about the merchant's online store **138**, such as based on account status, growth, recent customer activity, and the like. Notifications may be provided to assist a merchant with navigating through a process, such as capturing a payment, marking an order as fulfilled, archiving an order that is complete, and the like.

[0042] The e-commerce platform **100** may provide for a communications facility **129** and associated merchant interface for providing electronic communications and marketing, such as utilizing an electronic messaging aggregation facility for collecting and analyzing communication interactions between merchants, customers, merchant devices **102**, customer devices **150**, POS devices **152**, and the like, to aggregate and analyze the communications, such as for increasing the potential for providing a sale of a product, and the like. For instance, a customer may have a question related to a product, which may produce a dialog between the customer and the merchant (or automated processor-based agent representing the merchant), where the communications facility **129** analyzes the interaction and provides analysis to the merchant on how to improve the probability for a sale.

[0043] The e-commerce platform **100** may provide a financial facility **120** for secure financial transactions with customers, such as through a secure card server environment. The e-commerce platform **100** may store credit card information, such as in payment card industry data (PCI) environments (e.g., a card server), to reconcile financials, bill merchants, perform automated clearing house (ACH) transfers between an e-commerce platform **100** financial institution account and a merchant's bank account (e.g., when using capital), and the like. These systems may have Sarbanes-Oxley Act (SOX) compliance and a high level of diligence required in their development and operation. The financial facility **120** may also provide merchants with financial support, such as through the lending of capital (e.g., lending funds, cash advances, and the like) and provision of insurance. In addition, the e-commerce platform **100** may provide for a set of marketing and partner services and control the relationship between the e-commerce platform **100** and partners. They also may connect and onboard new merchants with the e-commerce platform **100**. These services may enable merchant growth by making it easier for merchants to work across the e-commerce platform **100**. Through these services, merchants may be provided help facilities via the e-commerce platform **100**.

[0044] In some embodiments, online store **138** may support a great number of independently administered storefronts and process a large volume of transactional data on a daily basis for a variety of products. Transactional data may include customer contact information, billing information, shipping information, information on products purchased, information on services rendered, and any other information associated with business through the e-commerce platform **100**. In some embodiments, the e-commerce platform **100**

may store this data in a data facility **134**. The transactional data may be processed to produce analytics **132**, which in turn may be provided to merchants or third-party commerce entities, such as providing consumer trends, marketing and sales insights, recommendations for improving sales, evaluation of customer behaviors, marketing and sales modeling, trends in fraud, and the like, related to online commerce, and provided through dashboard interfaces, through reports, and the like. The e-commerce platform **100** may store information about business and merchant transactions, and the data facility **134** may have many ways of enhancing, contributing, refining, and extracting data, where over time the collected data may enable improvements to aspects of the e-commerce platform **100**.

[0045] Referring again to FIG. **1**, in some embodiments the e-commerce platform **100** may be configured with a commerce management engine **136** for content management, task automation and data management to enable support and services to the plurality of online stores **138** (e.g., related to products, inventory, customers, orders, collaboration, suppliers, reports, financials, risk and fraud, and the like), but be extensible through applications **142**A-B that enable greater flexibility and custom processes required for accommodating an ever-growing variety of merchant online stores, POS devices, products, and services, where applications **142**A may be provided internal to the e-commerce platform **100** or applications **142**B from outside the e-commerce platform **100**. In some embodiments, an application **142**A may be provided by the same party providing the platform **100** or by a different party. In some embodiments, an application **142**B may be provided by the same party providing the platform **100** or by a different party. The commerce management engine **136** may be configured for flexibility and scalability through portioning (e.g., sharding) of functions and data, such as by customer identifier, order identifier, online store identifier, and the like. The commerce management engine **136** may accommodate store-specific business logic and in some embodiments, may incorporate the administrator **114** and/or the online store **138**.

[0046] The commerce management engine **136** includes base or "core" functions of the e-commerce platform **100**, and as such, as described herein, not all functions supporting online stores **138** may be appropriate for inclusion. For instance, functions for inclusion into the commerce management engine **136** may need to exceed a core functionality threshold through which it may be determined that the function is core to a commerce experience (e.g., common to a majority of online store activity, such as across channels, administrator interfaces, merchant locations, industries, product types, and the like), is re-usable across online stores **138** (e.g., functions that can be re-used/modified across core functions), limited to the context of a single online store **138** at a time (e.g., implementing an online store 'isolation principle', where code should not be able to interact with multiple online stores **138** at a time, ensuring that online stores **138** cannot access each other's data), provide a transactional workload, and the like. Maintaining control of what functions are implemented may enable the commerce management engine **136** to remain responsive, as many required features are either served directly by the commerce management engine **136** or enabled through an interface **140**A-B, such as by its extension through an application programming interface (API) connection to applications **142**A-B and channels **110**A-B, where interfaces **140**A may be provided to applications **142**A and/or channels **110**A inside the e-commerce platform **100** or through interfaces **140**B provided to applications **142**B and/or channels **110**B outside the e-commerce platform **100**. Generally, the platform **100** may include interfaces **140**A-B (which may be extensions, connectors, APIs, and the like) which facilitate connections to and communications with other platforms, systems, software, data sources, code and the like. Such interfaces **140**A-B may be an interface **140**A of the commerce management engine **136** or an interface **140**B of the platform **100** more generally. If care is not given to restricting functionality in the commerce management engine **136**, responsiveness could be compromised, such as through infrastructure degradation through slow databases or non-critical backend failures, through catastrophic infrastructure failure such as with a data center going offline, through new code being deployed that takes longer to execute than expected, and the like. To prevent or mitigate these situations, the commerce management engine **136** may be configured to maintain responsiveness, such as through configuration that utilizes timeouts, queues, back-pressure to prevent degradation, and the like.

[0047] Although isolating online store data is important to maintaining data privacy between online stores **138** and merchants, there may be reasons for collecting and using cross-store data, such as for example, with an order risk assessment system or a platform payment facility, both of which require information from multiple online stores **138** to perform well. In some embodiments, rather than violating the isolation principle, it may be preferred to move these components out of the commerce management engine **136** and into their own infrastructure within the e-commerce platform **100**.

[0048] In some embodiments, the e-commerce platform **100** may provide for a platform payment facility **120**, which is another example of a component that utilizes data from the commerce management engine **136** but may be located outside so as to not violate the isolation principle. The platform payment facility **120** may allow customers interacting with online stores **138** to have their payment information stored safely by the commerce management engine **136** such that they only have to enter it once. When a customer visits a different online store **138**, even if they've never been there before, the platform payment facility **120** may recall their information to enable a more rapid and correct check out. This may provide a cross-platform network effect, where the e-commerce platform **100** becomes more useful to its merchants as more merchants join, such as because there are more customers who checkout more often because of the ease of use with respect to customer purchases. To maximize the effect of this network, payment information for a given customer may be retrievable from an online store's checkout, allowing information to be made available globally across online stores **138**. It would be difficult and error prone for each online store **138** to be able to connect to any other online store **138** to retrieve the payment information stored there. As a result, the platform payment facility may be implemented external to the commerce management engine **136**.

[0049] For those functions that are not included within the commerce management engine **136**, applications **142**A-B provide a way to add features to the e-commerce platform **100**. Applications **142**A-B may be able to access and modify data on a merchant's online store **138**, perform tasks through

the administrator **114**, create new flows for a merchant through a user interface (e.g., that is surfaced through extensions/API), and the like. Merchants may be enabled to discover and install applications **142**A-B through application search, recommendations, and support **128**. In some embodiments, core products, core extension points, applications, and the administrator **114** may be developed to work together. For instance, application extension points may be built inside the administrator **114** so that core features may be extended by way of applications, which may deliver functionality to a merchant through the extension.

[0050] In some embodiments, applications **142**A-B may deliver functionality to a merchant through the interface **140**A-B, such as where an application **142**A-B is able to surface transaction data to a merchant (e.g., App: "Engine, surface my app data in mobile and web admin using the embedded app SDK"), and/or where the commerce management engine **136** is able to ask the application to perform work on demand (Engine: "App, give me a local tax calculation for this checkout").

[0051] Applications **142**A-B may support online stores **138** and channels **110**A-B, provide for merchant support, integrate with other services, and the like. Where the commerce management engine **136** may provide the foundation of services to the online store **138**, the applications **142**A-B may provide a way for merchants to satisfy specific and sometimes unique needs. Different merchants will have different needs, and so may benefit from different applications **142**A-B. Applications **142**A-B may be better discovered through the e-commerce platform **100** through development of an application taxonomy (categories) that enable applications to be tagged according to a type of function it performs for a merchant; through application data services that support searching, ranking, and recommendation models; through application discovery interfaces such as an application store, home information cards, an application settings page; and the like.

[0052] Applications **142**A-B may be connected to the commerce management engine **136** through an interface **140**A-B, such as utilizing APIs to expose the functionality and data available through and within the commerce management engine **136** to the functionality of applications (e.g., through REST, GraphQL, and the like). For instance, the e-commerce platform **100** may provide API interfaces **140**A-B to merchant and partner-facing products and services, such as including application extensions, process flow services, developer-facing resources, and the like. With customers more frequently using mobile devices for shopping, applications **142**A-B related to mobile use may benefit from more extensive use of APIs to support the related growing commerce traffic. The flexibility offered through use of applications and APIs (e.g., as offered for application development) enable the e-commerce platform **100** to better accommodate new and unique needs of merchants (and internal developers through internal APIs) without requiring constant change to the commerce management engine **136**, thus providing merchants what they need when they need it. For instance, shipping services **122** may be integrated with the commerce management engine **136** through a shipping or carrier service API, thus enabling the e-commerce platform **100** to provide shipping service functionality without directly impacting code running in the commerce management engine **136**.

[0053] Many merchant problems may be solved by letting partners improve and extend merchant workflows through application development, such as problems associated with back-office operations (merchant-facing applications **142**A-B) and in the online store **138** (customer-facing applications **142**A-B). As a part of doing business, many merchants will use mobile and web related applications on a daily basis for back-office tasks (e.g., merchandising, inventory, discounts, fulfillment, and the like) and online store tasks (e.g., applications related to their online shop, for flash-sales, new product offerings, and the like), where applications **142**A-B, through extension/API **140**A-B, help make products easy to view and purchase in a fast growing marketplace. In some embodiments, partners, application developers, internal applications facilities, and the like, may be provided with a software development kit (SDK), such as through creating a frame within the administrator **114** that sandboxes an application interface. In some embodiments, the administrator **114** may not have control over nor be aware of what happens within the frame. The SDK may be used in conjunction with a user interface kit to produce interfaces that mimic the look and feel of the e-commerce platform **100**, such as acting as an extension of the commerce management engine **136**.

[0054] Applications **142**A-B that utilize APIs may pull data on demand, but often they also need to have data pushed when updates occur. Update events may be implemented in a subscription model, such as for example, customer creation, product changes, or order cancelation. Update events may provide merchants with needed updates with respect to a changed state of the commerce management engine **136**, such as for synchronizing a local database, notifying an external integration partner, and the like. Update events may enable this functionality without having to poll the commerce management engine **136** all the time to check for updates, such as through an update event subscription. In some embodiments, when a change related to an update event subscription occurs, the commerce management engine **136** may post a request, such as to a predefined callback URL. The body of this request may contain a new state of the object and a description of the action or event. Update event subscriptions may be created manually, in the administrator facility **114**, or automatically (e.g., via the API **140**A-B). In some embodiments, update events may be queued and processed asynchronously from a state change that triggered them, which may produce an update event notification that is not distributed in real-time.

[0055] In some embodiments, the e-commerce platform **100** may provide application search, recommendation and support **128**. Application search, recommendation and support **128** may include developer products and tools to aid in the development of applications, an application dashboard (e.g., to provide developers with a development interface, to administrators for management of applications, to merchants for customization of applications, and the like), facilities for installing and providing permissions with respect to providing access to an application **142**A-B (e.g., for public access, such as where criteria must be met before being installed, or for private use by a merchant), application searching to make it easy for a merchant to search for applications **142**A-B that satisfy a need for their online store **138**, application recommendations to provide merchants with suggestions on how they can improve the user experience through their online store **138**, a description of core application capabilities within the commerce management engine

136, and the like. These support facilities may be utilized by application development performed by any entity, including the merchant developing their own application **142**A-B, a third-party developer developing an application **142**A-B (e.g., contracted by a merchant, developed on their own to offer to the public, contracted for use in association with the e-commerce platform **100**, and the like), or an application **142**A or **142**B being developed by internal personal resources associated with the e-commerce platform **100**. In some embodiments, applications **142**A-B may be assigned an application identifier (ID), such as for linking to an application (e.g., through an API), searching for an application, making application recommendations, and the like.

[0056] The commerce management engine **136** may include base functions of the e-commerce platform **100** and expose these functions through APIs **140**A-B to applications **142**A-B. The APIs **140**A-B may enable different types of applications built through application development. Applications **142**A-B may be capable of satisfying a great variety of needs for merchants but may be grouped roughly into three categories: customer-facing applications, merchant-facing applications, integration applications, and the like. Customer-facing applications **142**A-B may include online store **138** or channels **110**A-B that are places where merchants can list products and have them purchased (e.g., the online store, applications for flash sales (e.g., merchant products or from opportunistic sales opportunities from third-party sources), a mobile store application, a social media channel, an application for providing wholesale purchasing, and the like). Merchant-facing applications **142**A-B may include applications that allow the merchant to administer their online store **138** (e.g., through applications related to the web or website or to mobile devices), run their business (e.g., through applications related to POS devices), to grow their business (e.g., through applications related to shipping (e.g., drop shipping), use of automated agents, use of process flow development and improvements), and the like. Integration applications may include applications that provide useful integrations that participate in the running of a business, such as shipping providers **112** and payment gateways.

[0057] In some embodiments, an application developer may use an application proxy to fetch data from an outside location and display it on the page of an online store **138**. Content on these proxy pages may be dynamic, capable of being updated, and the like. Application proxies may be useful for displaying image galleries, statistics, custom forms, and other kinds of dynamic content. The core-application structure of the e-commerce platform **100** may allow for an increasing number of merchant experiences to be built in applications **142**A-B so that the commerce management engine **136** can remain focused on the more commonly utilized business logic of commerce.

[0058] The e-commerce platform **100** provides an online shopping experience through a curated system architecture that enables merchants to connect with customers in a flexible and transparent manner. A typical customer experience may be better understood through an embodiment example purchase workflow, where the customer browses the merchant's products on a channel **110**A-B, adds what they intend to buy to their cart, proceeds to checkout, and pays for the content of their cart resulting in the creation of an order for the merchant. The merchant may then review and fulfill (or cancel) the order. The product is then delivered to the customer. If the customer is not satisfied, they might return the products to the merchant.

[0059] In an example embodiment, a customer may browse a merchant's products on a channel **110**A-B. A channel **110**A-B is a place where customers can view and buy products. In some embodiments, channels **110**A-B may be modeled as applications **142**A-B (a possible exception being the online store **138**, which is integrated within the commence management engine **136**). A merchandising component may allow merchants to describe what they want to sell and where they sell it. The association between a product and a channel may be modeled as a product publication and accessed by channel applications, such as via a product listing API. A product may have many options, like size and color, and many variants that expand the available options into specific combinations of all the options, like the variant that is extra-small and green, or the variant that is size large and blue. Products may have at least one variant (e.g., a "default variant" is created for a product without any options). To facilitate browsing and management, products may be grouped into collections, provided product identifiers (e.g., stock keeping unit (SKU)) and the like. Collections of products may be built by either manually categorizing products into one (e.g., a custom collection), by building rulesets for automatic classification (e.g., a smart collection), and the like. Products may be viewed as 2D images, 3D images, rotating view images, through a virtual or augmented reality interface, and the like.

[0060] In some embodiments, the customer may add what they intend to buy to their cart (in an alternate embodiment, a product may be purchased directly, such as through a buy button as described herein). Customers may add product variants to their shopping cart. The shopping cart model may be channel specific. The online store **138** cart may be composed of multiple cart line items, where each cart line item tracks the quantity for a product variant. Merchants may use cart scripts to offer special promotions to customers based on the content of their cart. Since adding a product to a cart does not imply any commitment from the customer or the merchant, and the expected lifespan of a cart may be in the order of minutes (not days), carts may be persisted to an ephemeral data store.

[0061] The customer then proceeds to checkout. A checkout component may implement a web checkout as a customer-facing order creation process. A checkout API may be provided as a computer-facing order creation process used by some channel applications to create orders on behalf of customers (e.g., for point of sale). Checkouts may be created from a cart and record a customer's information such as email address, billing, and shipping details. On checkout, the merchant commits to pricing. If the customer inputs their contact information but does not proceed to payment, the e-commerce platform **100** may provide an opportunity to re-engage the customer (e.g., in an abandoned checkout feature). For those reasons, checkouts can have much longer lifespans than carts (hours or even days) and are therefore persisted. Checkouts may calculate taxes and shipping costs based on the customer's shipping address. Checkout may delegate the calculation of taxes to a tax component and the calculation of shipping costs to a delivery component. A pricing component may enable merchants to create discount codes (e.g., 'secret' strings that when entered on the checkout apply new prices to the items in the checkout). Discounts may be used by merchants to attract customers and assess

the performance of marketing campaigns. Discounts and other custom price systems may be implemented on top of the same platform piece, such as through price rules (e.g., a set of prerequisites that when met imply a set of entitlements). For instance, prerequisites may be items such as "the order subtotal is greater than $100" or "the shipping cost is under $10", and entitlements may be items such as "a 20% discount on the whole order" or "$10 off products X, Y, and Z".

[0062] Customers then pay for the content of their cart resulting in the creation of an order for the merchant. Channels **110**A-B may use the commerce management engine **136** to move money, currency or a store of value (such as dollars or a cryptocurrency) to and from customers and merchants. Communication with the various payment providers (e.g., online payment systems, mobile payment systems, digital wallet, credit card gateways, and the like) may be implemented within a payment processing component. The actual interactions with the payment gateways **106** may be provided through a card server environment. In some embodiments, the payment gateway **106** may accept international payment, such as integrating with leading international credit card processors. The card server environment may include a card server application, card sink, hosted fields, and the like. This environment may act as the secure gatekeeper of the sensitive credit card information. In some embodiments, most of the process may be orchestrated by a payment processing job. The commerce management engine **136** may support many other payment methods, such as through an offsite payment gateway **106** (e.g., where the customer is redirected to another website), manually (e.g., cash), online payment methods (e.g., online payment systems, mobile payment systems, digital wallet, credit card gateways, and the like), gift cards, and the like. At the end of the checkout process, an order is created. An order is a contract of sale between the merchant and the customer where the merchant agrees to provide the goods and services listed on the orders (e.g., order line items, shipping line items, and the like) and the customer agrees to provide payment (including taxes). This process may be modeled in a sales component. Channels **110**A-B that do not rely on commerce management engine **136** checkouts may use an order API to create orders. Once an order is created, an order confirmation notification may be sent to the customer and an order placed notification sent to the merchant via a notification component. Inventory may be reserved when a payment processing job starts to avoid over-selling (e.g., merchants may control this behavior from the inventory policy of each variant). Inventory reservation may have a short time span (minutes) and may need to be very fast and scalable to support flash sales (e.g., a discount or promotion offered for a short time, such as targeting impulse buying). The reservation is released if the payment fails. When the payment succeeds, and an order is created, the reservation is converted into a long-term inventory commitment allocated to a specific location. An inventory component may record where variants are stocked, and tracks quantities for variants that have inventory tracking enabled. It may decouple product variants (a customer facing concept representing the template of a product listing) from inventory items (a merchant facing concept that represent an item whose quantity and location is managed). An inventory level component may keep track of quantities that are available for sale, committed to an order or incoming from an inventory transfer component (e.g., from a vendor).

[0063] The merchant may then review and fulfill (or cancel) the order. A review component may implement a business process merchant's use to ensure orders are suitable for fulfillment before actually fulfilling them. Orders may be fraudulent, require verification (e.g., ID checking), have a payment method which requires the merchant to wait to make sure they will receive their funds, and the like. Risks and recommendations may be persisted in an order risk model. Order risks may be generated from a fraud detection tool, submitted by a third-party through an order risk API, and the like. Before proceeding to fulfillment, the merchant may need to capture the payment information (e.g., credit card information) or wait to receive it (e.g., via a bank transfer, check, and the like) and mark the order as paid. The merchant may now prepare the products for delivery. In some embodiments, this business process may be implemented by a fulfillment component. The fulfillment component may group the line items of the order into a logical fulfillment unit of work based on an inventory location and fulfillment service. The merchant may review, adjust the unit of work, and trigger the relevant fulfillment services, such as through a manual fulfillment service (e.g., at merchant managed locations) used when the merchant picks and packs the products in a box, purchase a shipping label and input its tracking number, or just mark the item as fulfilled. A custom fulfillment service may send an email (e.g., a location that doesn't provide an API connection). An API fulfillment service may trigger a third party, where the third-party application creates a fulfillment record. A legacy fulfillment service may trigger a custom API call from the commerce management engine **136** to a third party (e.g., fulfillment by Amazon). A gift card fulfillment service may provision (e.g., generating a number) and activate a gift card. Merchants may use an order printer application to print packing slips. The fulfillment process may be executed when the items are packed in the box and ready for shipping, shipped, tracked, delivered, verified as received by the customer, and the like.

[0064] If the customer is not satisfied, they may be able to return the product(s) to the merchant. The business process merchants may go through to "un-sell" an item may be implemented by a return component. Returns may consist of a variety of different actions, such as a restock, where the product that was sold actually comes back into the business and is sellable again; a refund, where the money that was collected from the customer is partially or fully returned; an accounting adjustment noting how much money was refunded (e.g., including if there was any restocking fees, or goods that weren't returned and remain in the customer's hands); and the like. A return may represent a change to the contract of sale (e.g., the order), and where the e-commerce platform **100** may make the merchant aware of compliance issues with respect to legal obligations (e.g., with respect to taxes). In some embodiments, the e-commerce platform **100** may enable merchants to keep track of changes to the contract of sales over time, such as implemented through a sales model component (e.g., an append-only date-based ledger that records sale-related events that happened to an item).

Managing Display Space Using an e-Commerce Platform

[0065] Retail merchants are merchants that own and/or operate a retail store, which may be a physical or "brick and mortar" store that customers can physically visit to purchase

products. Retail stores typically include shelf space to display products. As used herein, shelf space refers to any space in a retail store that can be used to display a product. Shelf space is not limited to physical shelves, and more generally includes floor space, walls, bins, racks, cabinets and any other means for displaying products in a retail store. Retail stores may also include advertising space or signage space, in which advertisements for products and/or services can be displayed to customers inside of and/or outside of the retail store. Non-limiting examples of advertising space include wall or window space to display signs or posters, ceiling space to hang banners, and floor space to present product demonstrations. The term "display space" is used to encompass both shelf space and advertising space. Display space can be quantified as a two-dimensional (2D) or three-dimensional (3D) space.

[0066] Retail stores that are implemented using virtual reality (VR) or augmented reality (AR) are also contemplated. AR or VR retail stores can include virtual shelf space or advertising space for products.

[0067] Retail merchants might use the display space in their retail stores to sell and/or advertise their own products, but this is not always the case. Instead, retail merchants may sell (or lease) display space within their retail stores to product merchants. Product merchants are merchants that design, manufacture, procure or otherwise obtain products to be sold to customers. To sell these products, the product merchants might use an online store, a retail store, or a combination thereof. Retail stores have the advantage that customers can physically interact with a product and the product can be displayed alongside other related products. However, there is typically a relatively large cost associated with owning and managing a retail store, and many product merchants cannot justify such a cost. Accordingly, product merchants may opt to purchase (or lease) display space in a retail store that is owned by a retail merchant. In some cases, even if a product merchant owns their own retail store, they might choose to further expand sales by purchasing display space in another retail store.

[0068] The cost of purchasing display space within a retail store may be referred to as "slotting fees" or "slotting allowances". After purchasing display space within a retail store, a product merchant can display their products and/or advertisements in this display space and profit from any sales of the products made through the retail store. Benefits of this approach for the product merchant may include:

[0069] Reducing or removing the cost associated with owning and managing a retail store;

[0070] Having products displayed in a retail store that has established customers; and

[0071] Having products displayed alongside similar products.

[0072] By way of example, a grocery store may be a retail store that sells display space to product merchants to display and sell their products.

[0073] Display space in retail stores can be a limited and desired commodity for merchants. In general, the value of display space is not equal across different regions of a retail store. For example, a product may exhibit better sales when displayed in a first region of a retail store compared to a second region of the same retail store. The first region may be in a popular location of the retail store that receives a relatively large amount of customer attention, whereas the second region may be in a remote location of the retail store that receives little customer attention. Determining the value of display space for different regions of a retail store can be a challenge for retail merchants.

[0074] The e-commerce platform **100** of FIG. **1** can be configured to generate or otherwise determine a value associated with displaying products in a region of a retail store. FIG. **3** illustrates the e-commerce platform **100**, but including a display space management engine **300**. The display space management engine **300** is an example of a computer-implemented system for managing display space in a location (for example, a retail store), including but not limited to determining values of the display space in the location. In some cases, retail merchants may use the display space management engine **300** to determine the value of display space in multiple different regions of their retail store. The retail merchant could then determine a price that the display space in each region will be sold for. The retail merchant could also or instead use the determined value of display space to improve the layout of the retail store and/or improve product placement within the retail store. The display space management engine **300** can also be used by product merchants. For example, product merchants may use the display space management engine **300** to determine which retail stores and which regions of those retail stores are suitable to display their products. Other potential functionality of a display space management engine is discussed elsewhere herein.

[0075] Although the display space management engine **300** is illustrated as a distinct component of the e-commerce platform **100** in FIG. **3**, this is only an example. A display space management engine could also or instead be provided by another component of the e-commerce platform **100**. In some embodiments, either or both of the applications **142**A-B provide a display space management engine that is available to merchants. Furthermore, in some embodiments, the commerce management engine **136** provides a display space management engine. The e-commerce platform **100** could include multiple display space management engines that are provided by one or more parties. The multiple display space management engines could be implemented in the same way, in similar ways and/or in distinct ways. In addition, at least a portion of a display space management engine could be implemented on the merchant device **102**. For example, the merchant device **102** could store and run the display space management engine locally as a software application.

[0076] As discussed in further detail below, the display space management engine **300** could implement at least some of the functionality described herein. Although the embodiments described below may be implemented in association with an e-commerce platform, such as (but not limited to) the e-commerce platform **100**, the embodiments described below are not limited to the specific e-commerce platform **100** of FIGS. **1** to **3**. Moreover, embodiments described herein do not necessarily need to be implemented in association with or involve an e-commerce platform at all. Therefore, some of the embodiments below are presented more generally in relation to any display space management engine.

Evaluating Display Space in a Retail Store

[0077] Retail merchants have struggled to evaluate display space within their retail stores in a manner that is reliable, accurate and unbiased. Similarly, product merchants have

struggled to determine how display space in a particular region of a retail store might meet their needs.

[0078] One method for determining the value of display space in a region of a retail store is estimating the popularity of the region with customers. More popular regions are generally those that are expected to be exposed to higher levels of customer traffic, and therefore display space in these regions may warrant a higher value. In some cases, the relative location of a region in a retail store may be used as an indication of the region's expected popularity. For example, a larger number of customers might enter a region that is central in the retail store, is near the entrance of the retail store, is near the end of an aisle, or is near a cashier. In contrast, a smaller number of customers might enter a region that is on the periphery of the retail store. Further, the vertical position of the region relative to the average height of a customer (for example, near eye level or above the customer's head) may also or instead be used as an indication of the region's expected popularity. However, estimating the value of display space in a region based on qualitative properties, rather than quantitative properties, may lead to biased and inaccurate evaluations of the display space. For example, the expected popularity of a region might not correspond to the actual real-world popularity of the region. Furthermore, before purchasing display space in a particular region of a retail store, a product merchant might want to view data that justifies the cost of the display space. Such data would generally not be available using the method described above.

[0079] Another method for determining the value of display space in a region of a retail store is to compare real-world product sales across different regions of the retail store. However, this method also has some significant drawbacks. For instance, sales of a product are highly dependent on the desirability of the product. Therefore, if a relatively undesirable product is displayed in a region of a retail store for a relatively long period of time, then this might artificially reduce the perceived value of this region for displaying products. The opposite may be true for relatively desirable products. As such, using this method, the desirability of the products that are displayed in different regions of a retail store can bias the value of display space in those different regions. In addition, sales data might include confidential information or personally identifiable information (PII), relating to customers and/or merchants, that a retail merchant is not permitted to share with a product merchant. Thus, the product merchant might not be able to view the data that justifies the cost of display space and as a result might be less inclined to purchase the display space.

[0080] In view of the foregoing, a need exists for systems and methods that can determine the value of display space in a location and improve upon the reliability and accuracy of conventional methods.

[0081] According to an aspect of the present disclosure, a value of displaying products in a region of a retail store is determined based on a measured traffic density in the region. Traffic density is used as a metric for real-world customer activity and/or customer patterns in the retail store. Traffic density may quantify or otherwise indicate the number of customers and/or shopping carts that a region of a retail store will be exposed to. Traffic density may also quantify or otherwise indicate the amount of engagement that an average customer has with products being displayed in a region of a retail store. It should be noted that traffic density is not limited to an amount of traffic per unit area or per unit volume. Traffic density can also include a total amount of traffic and/or an amount of traffic per unit time, for example. In some cases, regions with a high traffic density are regions in which a relatively large number of customers spend a longer amount of time compared to low traffic density regions. Accordingly, the sales of a product displayed in a high traffic density region are typically higher than the sales of the same product displayed in a low traffic density region. Using traffic density as a metric, the value of display space in a region of a retail store can be determined based on real-world data that does not include confidential information or PII.

[0082] Reference will now be made to FIG. **4**, which is a block diagram illustrating an example system **400** for determining traffic densities and evaluating display space for a retail store **401**. The retail store **401** includes several regions (not shown), each including 2D or 3D display space. A region could be defined by a shelf, a shelving unit, a wall area or a floor area of the retail store **401**, for example.

[0083] It should be noted that the system **400** is in no way limited to use with the retail store **401** or even to retail stores in general. The system **400** can more generally be implemented for locations other than retail stores, including museums, stadiums and libraries, for example. The system **400** can also be used to determine traffic densities and evaluate display space for multiple locations in parallel. Furthermore, the system **400** is not limited to use with physical retail stores and can also be implemented for virtual products and/or virtual retail stores that are provided using augmented reality (AR) or virtual reality (VR), for example.

[0084] The system **400** includes a display space management engine **402**, one or more sensor(s) **420**, a network **422**, and two merchant devices **430**, **440**. While FIG. **4** shows the sensor(s) **420** implemented inside of the retail store **401**, and the display space management engine **402** and the two merchant devices **430**, **440** implemented outside of the retail store **401**, this is only an example. The display space management engine **402** and/or either or both of the merchant devices **430**, **440** could instead be implemented at least partially inside of the retail store **401**. Furthermore, at least some of the sensor(s) **420** may be implemented outside of the retail store **401**.

[0085] The sensor(s) **420** are used to obtain measurements from the retail store **401**. Various implementations of the sensor(s) **420** in the retail store **401** are contemplated. Moreover, a combination of multiple different sensor implementations could be used to gather more detailed measurements for the retail store **401**. Non-limiting examples of different sensor implementations in the retail store **401** include:

- **[0086]** Implementing sensors on or in the ceiling of the retail store **401**. This can provide a top-down view of the retail store **401**, which might be best suited to generating a 2D spatial map of the retail store **401** (e.g., along a plane parallel to the ceiling of the retail store **401**).
- **[0087]** Implementing sensors on or in the walls of the retail store **401**. This can provide a side or lateral view of the retail store **401**.
- **[0088]** Implementing the sensors at the junction between a wall and a ceiling in the retail store **401**. This can obtain measurements of the retail store **401** from an oblique angle.

[0089] The measurements obtained by the sensor(s) **420** provide spatial and/or temporal information that can be used to determine traffic densities for one or more regions of the retail store **401**. In order to accurately determine a traffic density, it might be desired that a sensor or collection of sensors have any, one, some or all of the following features and capabilities:

[0090] Have a sufficient resolution to detect customers and distinguish between different customers. For example, the sensor should be able to distinguish between two customers that are walking side-by-side.

[0091] Have a sufficient resolution to detect certain objects and distinguish between objects and customers. For example, the sensor should be able to distinguish between a shopping cart and a customer using the shopping cart.

[0092] Have a sufficient resolution to detect certain actions performed by a customer, such as the customer reaching out to interact with a product on a shelf, for example.

[0093] Have a sufficient range to detect customers and objects at various distances.

[0094] Be capable of acquiring a 2D spatial map or layout for the retail store **401** that identifies any, some or all objects, customers and fixed structures within the retail store **401**.

[0095] Be capable of acquiring 3D spatial information for the retail store **401**.

[0096] Be capable of acquiring speed or velocity information to determine if a customer or an object is moving or is stationary.

[0097] Be capable of tracking an object or customer through the retail store **401** over time.

[0098] Be capable of acquiring biometric information for a customer, such as the heart rate or breathing rate of the customer, for example. This biometric information could provide an indication of a customer's mood and/or level of interest in a region of the retail store **401**.

[0099] Be capable of acquiring demographic information, such as gender or age, for example. This data could be used to divide traffic density data across different categories or segments of customers.

[0100] Be adjustable or tunable to provide different capabilities. For example, the sensor could be adjustable to switch between obtaining low resolution (or coarse) measurements of multiple customers in a large area and obtaining high resolution (or fine) measurements of one customer in a smaller area.

[0101] Avoid collecting any confidential information or PII. In some cases, PII can fall within certain regulations that limits how the information may be used. For example, visual images of customers within a retail store might be considered to contain PII. Avoiding the collection of any data containing PII can reduce the limitations imposed on the generation, storage and use of the data.

[0102] Be relatively low-cost.

[0103] Be easily implemented in the retail store **401**.

[0104] The sensor(s) **420** may include one or more different types of sensors. Non-limiting examples of such sensor types include:

[0105] Sensors that perform radio wave measurements, such as radar sensors, for example;

[0106] Sensors that perform acoustic measurements, such as echolocation sensors, for example;

[0107] Sensors that detect WI-FI signals from customer devices;

[0108] Thermal sensors;

[0109] Lidar sensors; and

[0110] Foot traffic sensors.

[0111] In some implementations, radar sensors may provide any, one, some or all of the features and capabilities identified above. By way of example, the TI IWR6843 Single-Chip 60- to 64-GHz mmWave Sensor could be used as a radar sensor for determining traffic density. In some cases, a radar sensor emits a series of radio wave pulses in the 60-64 GHz frequency range. The pulses may be reflected off entities (for example, customers or objects) and be received by the radar sensor. The time-of-flight of the pulse can provide a measurement of an entity's distance from the radar sensor, and the Doppler shift of the pulse can provide a measurement of the entity's velocity. Further, the direction that the pulse is transmitted in, or received from, can provide a measurement of the entity's position relative to the radar sensor. Advantageously, radar sensors do not typically collect PII, and therefore can avoid the issues associated with PII discussed above.

[0112] A radar sensor might be sensitive to the type of material being detected, and in particular to the dielectric constant of the material. Materials with high dielectric constants (for example, metals) might reflect radio wave pulses relatively strongly and produce a high signal-to-noise ratio (SNR), whereas materials with lower dielectric constants (for example, hair) might reflect radio wave pulses relatively weakly and produce a low SNR. In general, clothing and human bodies reflect radio wave pulses to a medium degree.

[0113] Parameters of a sensor may be intermittently and/or continuously adjusted in order to vary the SNR, sensitivity, resolution and/or range of the measurements obtained by the sensor, for example. In the case of a radar sensor, the parameters that may be adjusted include threshold power for detection (for example, the minimum power of a reflected pulse that is recorded as the detection of an object), pulse power, pulse bandwidth, pulse duration, pulse chirp and pulse repetition rate, for example. However, there may be trade-offs associated with adjusting the parameters of a sensor. For example, improving the spatial or temporal resolution of a radar sensor may reduce the range of the radar sensor.

[0114] In some implementations, parameters of a sensor might be actively adjusted to achieve different measurement capabilities for different situations. For example, a radar sensor could be initially configured to obtain measurements over a relatively large range but with a relatively low resolution. Once an entity is detected, the radar sensor could then be adjusted to improve the measurement resolution in the region of the entity. This may help detect certain properties of the entity, such as if the entity is a customer or a shopping cart, the velocity of the entity and the shape of the entity, for example.

[0115] Although not illustrated in FIG. **4**, one or more of the sensor(s) **420** may include or be connected to: memory for storing measurements and/or sensor parameters; a processor for processing measurements and/or adjusting sensor parameters; and a network interface for communicating over the network **422**.

[0116] The display space management engine **402** performs operations related to managing display space. One such operation is determining traffic densities and evaluating display space in the retail store **401** based on measurements obtained from the sensor(s) **420**. However, the display space management engine **402** can also perform other operations, including but not limited to:

[0117] Storing layouts, measurements, traffic densities and/or values of display space for various locations;

[0118] Outputting the layouts, measurements, traffic densities and/or values of display space to other devices such as merchant devices, for example; and

[0119] Facilitating the purchase of display space.

[0120] In some implementations, the display space management engine **402** is provided within the retail store **401**. However, the display space management engine **402** could instead be remote from the retail store **401**. In some implementations, the display space management engine **402** is provided at least in part by an e-commerce platform, either as a core function of the e-commerce platform or as an application supported by the e-commerce platform. For example, the display space management engine **402** could be the display space management engine **300** of FIG. **3**. In some implementations, the display space management engine **402** is implemented at least in part by a user device such as a merchant device. Other implementations of the display space management engine **402** are also contemplated. While the display space management engine **402** is shown as a single component in FIG. **4**, the display space management engine **402** could instead be provided by multiple different components that are in communication via the network **422**, for example.

[0121] The display space management engine **402** includes a processor **404**, memory **406** and a network interface **408**. The processor **404** may be implemented by one or more processors that execute instructions stored in the memory **406**. These instructions could implement any method described herein. Alternatively, some or all of the processor **404** may be implemented using dedicated circuitry, such as an application specific integrated circuit (ASIC), a graphics processing unit (GPU) or a programmed field programmable gate array (FPGA).

[0122] The network interface **408** is provided for communication over the network **422**. The structure of the network interface **408** is implementation specific. For example, the network interface **408** may include a network interface card (NIC), a computer port (e.g., a physical outlet to which a plug or cable connects), and/or a network socket.

[0123] The memory **406** includes a location record **410**, a measurement record **412**, a traffic density record **414** and a display space value record **416**. In some implementations, the location record **410**, the measurement record **412**, the traffic density record **414** and the display space value record **416** are stored as one or more data structures in the memory **406**. Non-limiting examples of such data structures include lists, arrays (of any dimension) and data trees.

[0124] The location record **410** stores information relating to the locations that are managed by the display space management engine **402**. At least one of these locations is the retail store **401**, but information relating to other retail stores, museums, stadiums and/or libraries may also be stored in the location record **410**. For a given location, the information stored in the location record **410** may include, inter alia:

[0125] The address of the location;

[0126] The owner of the location (for example, the retail merchant associated with the retail store **401**);

[0127] The purpose or function of the location (for example, is the location a retail store or a stadium);

[0128] A list of the different regions in the location and any display space available in each region;

[0129] The layout of the location, which may indicate the boundaries of each region in the location and/or the fixed structures in the location, for example; and

[0130] Any product merchants that have purchased or leased display space in the location.

[0131] In some implementations, any, some or all of the information stored in the location record **410** may be provided by a merchant via a merchant device, for example. However, as discussed in further detail below, at least some of this information may be generated from measurements.

[0132] The measurement record **412** stores measurements for the locations listed in the location record **410**. At least some of these measurements are obtained from the sensor(s) **420** and correspond to the retail store **401**, but measurements from other sensors that correspond to other locations can also be stored in the measurement record **412**. In some implementations, the measurements are transmitted from the sensor(s) **420** to the display space management engine **402** via the network **422**. However, the network **422** might not be used to communicate measurements in all cases. For example, a direct wired or wireless communication link (not shown) between the display space management engine **402** and the sensor(s) **420** may allow measurements to be transmitted to the display space management engine **402** without the use of the network **422**.

[0133] In some implementations, the measurements stored in the measurement record **412** include spatial information that indicates the position, shape and/or velocity of one or more entities in the retail store **401**, including structural components, people and objects in the retail store **401**, for example. Consider the case of measurements that are obtained from a radar sensor. These measurements can be stored as 2D or 3D spatial data points, which may also be considered spatial data points ("dots") within a 2D or 3D space. Each spatial data point corresponds to a measurement from the radar sensor. An area having a dense collection of spatial data points may indicate the presence of an entity, and an area having a sparse collection of spatial data points or no spatial data points at all may be an area of empty space. A spatial data point could also have an associated speed and/or velocity that was measured by the radar sensor.

[0134] Spatial information obtained from the sensor(s) **420** could be mapped to (or superimposed with) a layout of the retail store **401** that is stored in the location record **410**. For example, spatial data points could be defined in terms of a coordinate system that corresponds to a coordinate system used to define the layout of the retail store **401**. The mapping could determine the position of people and/or objects relative to the different regions of the retail store **401**, for example. Further, the mapping could determine the position of people and/or objects relative to each other and to fixed structures in the retail store **401**.

[0135] In some implementations, the measurement record **412** includes spatial information for the retail store **401** that was acquired when the retail store **401** is empty of any customers and/or products. Therefore, this spatial information may identify only the fixed structures within the retail

store **401**, such as the walls and shelves, for example. Using this spatial information, the layout of the retail store **401** can be determined and stored in the location record **410**. The fixed structures within the retail store **401** can then be accounted for when obtaining future measurements.

[0136] In some implementations, the measurements stored in the measurement record **412** include temporal information that indicates the movement of one or more entities over time. For example, spatial data points that are collected over a period of time can be used to monitor and track the movement of a person or an object.

[0137] Raw measurements may be processed before they are stored in the measurement record **412**. For example, in the case of a radar sensor, processing may be used to generate spatial data points from the time-of-flight, Doppler shift and direction of pulses received by the radar sensor. Algorithms (stored in the form of computer-executable instructions) for processing raw measurements may be stored by the memory **406** and/or by the sensor(s) **420**. In some implementations, processing is performed by the sensor(s) **420** before measurements are transmitted to the display space management engine **402**. As such, the measurements might be received in a form that is suitable for storage in the measurement record **412**. Alternatively, at least some processing of the measurements may be performed by the processor **404** in the display space management engine **402**.

[0138] Measurements can be intermittently and/or continuously received by the display space management engine **402** from the sensor(s) **420** and other sensors. As such, new measurements can be added to the measurement record **412** when they become available. In some implementations, older measurements may be deleted from the measurement record **412** when new measurements are received.

[0139] The traffic density record **414** stores traffic densities for the locations listed in the location record **410**. At least some of these traffic densities correspond to the retail store **401**, where each region of the retail store **401** can have a corresponding traffic density. However, traffic densities for other locations may also be stored in the traffic density record **414**.

[0140] In some implementations, the traffic densities stored in the traffic density record **414** are determined by the display space management engine **402** based on the measurements stored in the measurement record **412**. For example, the memory **406** can store algorithms (in the form of computer-executable instructions) for generating traffic densities from the measurements. These algorithms, which can be executed by the processor **404**, obtain measurements from the measurement record **412** and analyse the measurements to calculate traffic densities. In some implementations, a traffic density is determined based on analysis of a large amount of measurement data originating from multiple sensors over a period of time. The determination of traffic density can be performed separately for each region of the retail store **401**.

[0141] Analysis of the measurements in the measurement record **412** can detect the presence of a customer in a region of the retail store **401**. For example, the presence of a customer could be determined based on the shape of a cluster of spatial data points in the region. The analysis could also determine a position and/or velocity of the customer and track the customer as they move through the retail store **401**. Similar comments apply to detecting, locating and tracking other entities such as shopping carts, for example. The presence, position and/or velocity of the entities in the retail store **401** can be used to help determine traffic densities for the retail store **401**.

[0142] The actions of a customer can also be determined through the analysis of the measurements in the measurement record **412**. In some implementations, the actions of a customer are determined based on the position and/or movement of various anatomical features of the customer, non-limiting examples of which include the customer's torso, head, arms and legs. For example, a cluster of spatial data points might provide enough detail to determine which data points correspond to the torso, head, arms and legs of a customer. Once detected, various actions of a customer could be discerned through the movement of their anatomical features. As an example, the movement of a customer's arm towards a shelf in the retail store **401** could be interpreted as the customer interacting with a product. Using 3D spatial information, the analysis can determine the vertical height at which a customer is interacting with a product, which may allow traffic densities to be determined in 3D. Measurement analysis may also be able to detect various devices or objects that a customer is holding, which could be used to detect when a customer is picking up a product and adding that product to a shopping cart. The actions of a customer in a region of the retail store **401** can be used to help determine a traffic density in that region.

[0143] Improving the resolution of spatial data points may enable more accurate measurement analysis. For example, improving the spatial resolution could allow the position, velocity and/or actions of customers to be determined with a higher degree of accuracy.

[0144] In general, analysis of the measurements stored in the measurement record **412** can provide information that defines, or is used to determine, a traffic density for a region of the retail store **401**. By way of example, traffic density in a region could be based on any, some or all of the following information:

- **[0145]** The number of customers that enter the region over a given period of time. In some cases, the number of customers that enter the region is normalized based on the total area or total volume of the region. For example, a number of customers per square meter could be determined for the region and used to define traffic density.
- **[0146]** The average time that a customer spends in the region. Customers might spend a longer amount of time in regions with many sought-after products, or regions that are spacious and/or visually pleasing compared to regions that are narrow, congested, dark or otherwise unappealing.
- **[0147]** The number of customer-product interactions within the region. Customer-product interactions could include customers stopping to look at products, picking up or otherwise manipulating products, and/or placing products in a shopping cart (or basket) within the region. Customer-product interactions may be counted over a period of time or averaged on a per customer basis, for example.
- **[0148]** The number of shopping carts that enter the region over a given period of time. The presence of a shopping cart may be an indication that the customer utilizing the shopping cart intends to purchase a product, intends to purchase multiple products, and/or intends to purchase bulkier products.

[0149] Biometric information for customers in the region, which can provide an indication of a customer's mood and/or level of interest in the region.

[0150] In some implementations, measurement analysis can determine the age and/or other demographic information for one or more customers. This may be achieved by determining the height of the customers, for example. The traffic densities stored in the traffic density record **414** can then be divided across different categories or segments of customers based on this demographic information. For example, measurement analysis could determine that regions at a certain vertical height in the retail store **401** have a high traffic density for children, but less so for adults. This demographic information could be interesting to a product merchant that has purchased display space in a region at this height and is deciding what products to place in the display space. In view of the demographic information, the product merchant could choose to display products aimed at children.

[0151] Since traffic densities are determined, generated or calculated based on measurements stored in the measurement record **412**, traffic densities in the traffic density record **414** can be intermittently or continuously updated as new measurements become available.

[0152] The display space value record **416** stores a display space value for each region of the locations listed in the location record **410**. In some implementations, the values of display space are determined based on the corresponding traffic densities stored in the traffic density record **414**. In the retail store **401**, display space may be evaluated on a per-shelf basis or a per-rack basis. Alternatively, display space may be evaluated per unit area (for example, a 2D area on a shelf) or per unit volume, for example. The value of display space may be defined in terms of a price or cost of purchasing the display space, but this might not always be the case. Other metrics could be used to define or quantify the value of display space.

[0153] In some implementations, the memory **406** can store algorithms (in the form of computer-executable instructions) for generating values of display space. These algorithms, which can be executed by the processor **404**, query the traffic density record **414** to obtain traffic densities and determine the corresponding display space values. Any of a variety of different approaches can be used to determine the display space values.

[0154] In some implementations, the value of display space is determined using a comparative approach. For example, the traffic densities for multiple regions can be compared, and the regions with higher relative traffic densities can be assigned a higher value of display space. Comparing the traffic densities of multiple regions is not limited to regions of a single location. For example, traffic densities for regions of multiple retail stores can be compared to perhaps more accurately determine appropriate values of display space.

[0155] In some implementations, the value of display space in a region is determined based on whether a traffic density for that region exceeds one or more thresholds. For example, thresholds could be defined in terms of the number of customers that enter the region; the average time that a customer spends in the region; the number of customer-product interactions in the region; and/or the number of shopping carts that enter the region. Each traffic density threshold that a region exceeds could increase the value of display space in that region by a predefined amount. The following is a non-limiting list of example traffic density thresholds:

[0156] 100 customers entering the region on an average day;

[0157] 200 customers entering the region on an average day;

[0158] 500 customers entering the region on an average day;

[0159] 1000 customers entering the region on an average day;

[0160] The average customer spending 10 seconds in the region;

[0161] The average customer spending 30 seconds in the region;

[0162] The average customer spending 1 minute in the region;

[0163] The average customer spending 2 minutes in the region;

[0164] The average customer interacting with **1** product in the region;

[0165] The average customer interacting with **2** products in the region;

[0166] The average customer interacting with **5** products in the region;

[0167] The average customer interacting with **10** products in the region;

[0168] 100 shopping carts entering the region on an average day;

[0169] 200 shopping carts entering the region on an average day;

[0170] 500 shopping carts entering the region on an average day; and

[0171] 1000 shopping carts entering the region on an average day.

[0172] The display space management engine **402** could determine values of display space for different locations and/or regions in the same way, but this might not always be the case. In some implementations, different locations and/or regions may have specific methods for analysing measurements, determining traffic densities and/or determining values of display space.

[0173] Although the location record **410**, the measurement record **412**, the traffic density record **414** and the display space value record **416** are illustrated as separate records, this is only an example. Some embodiments could combine these records as a single record or data structure. For example, a single data structure could store a layout, measurements, traffic densities and display space values for multiple locations.

[0174] The algorithms that are used by the display space management engine **402** to analyse measurements, determine traffic densities and determine values of display space could be implemented by one or more models stored in the memory **406**. In some implementations, measurements from the measurement record **412** could be analysed multiple times by different models to provide more information for determining traffic densities and determining values of display space. By way of example, different models could use different thresholds for determining when a cluster of spatial data points corresponds to an object. A first model could have a relatively high threshold that is configured for reliably detecting the presence of customers, whereas a second model could have a relatively low threshold that is

configured for detecting smaller objects such as a customer's hand. These two models could be used in conjunction, where the first model is used to detect a customer and the second model is used to better characterize the customer by detecting various anatomical features of the customer. A traffic density could be determined based on the outputs of both models.

[0175] In some implementations, machine learning (ML) models can be implemented by the display space management engine **402** to analyse measurements, determine traffic densities and/or determine values of display space. Possible inputs to the ML model include information from the location record **410**, measurements from the measurement record **412** and/or traffic densities from the traffic density record **414**. Possible outputs from the ML model include traffic densities and values of display space. An ML model could be implemented using any form or structure known in the art. Example structures for the ML model include but are not limited to:

[0176] One or more artificial neural network(s);

[0177] One or more decision tree(s);

[0178] One or more support vector machine(s);

[0179] One or more Bayesian network(s); and/or

[0180] One or more genetic algorithm(s).

[0181] An ML model could be trained using data samples with traffic densities and/or display values that have been previously determined using other means. In some embodiments, the ML model is trained using information in the traffic density record **414** and/or the display space value record **416**. The method used to train the ML model is implementation specific and is not limited herein. Non-limiting examples of training methods include:

[0182] Supervised learning;

[0183] Unsupervised learning;

[0184] Reinforcement learning;

[0185] Self-learning;

[0186] Feature learning; and

[0187] Sparse dictionary learning.

[0188] The merchant devices **430**, **440** in the system **400** are examples of user devices. The merchant device **430** is associated with a retail merchant that owns the retail store **401** and the merchant device **440** is associated with a product merchant that is interested in purchasing display space in the retail store **401** and/or has already purchased display space in the retail store **401**.

[0189] Either or both of the merchant devices **430**, **440** may be a mobile phone, tablet, laptop, or computer, for example. The merchant device **430** includes a processor **432**, memory **434**, user interface **436**, and network interface **438**. Similarly, the merchant device **440** includes a processor **442**, memory **444**, user interface **446**, and network interface **448**. An example of a user interface is a display screen (which may be a touch screen), headset, a keyboard, and/or a mouse. The network interfaces **438**, **448** are provided for communicating over the network **422**. The structure of the network interfaces **438**, **448** will depend on how each of the merchant devices **430**, **440** interfaces with the network **422**. For example, if the merchant device **430** is a mobile phone or tablet, the network interface **438** may include a transmitter/receiver with an antenna to send and receive wireless transmissions to/from the network **422**. If the merchant device **430** is a personal computer connected to the network with a network cable, the network interface **438** may include, for example, a NIC, a computer port, and/or a network socket. Similar comments apply to the merchant device **440** and the network interface **448**. The processors **432**, **442** directly perform or instruct all of the operations performed by the merchant devices **430**, **440**, respectively. Examples of these operations include processing user inputs received from the user interfaces **436**, **446**, preparing information for transmission over the network **422**, processing data received over the network **422**, and instructing a display screen to display information. Either or both of the processors **432**, **442** may be implemented by one or more processors that execute instructions stored in the memory **434**, **444**, respectively. Alternatively, some or all of the processors **432**, **442** may be implemented using dedicated circuitry, such as an ASIC, a GPU, or a programmed FPGA.

[0190] Content can be communicated between the display space management engine **402** and the merchant devices **430**, **440**. This content can include any, some or all of the information that is stored in the location record **410**, the measurement record **412**, the traffic density record **414** and/or the display space value record **416**. In some implementations, the display space management engine **402** and the merchant devices **430**, **440** communicate via the network **422**. However, a direct wired or wireless connection (not shown) could be established between the display space management engine **402** and either or both of the merchant devices **430**, **440**.

[0191] In some implementations, using the merchant device **430**, the retail merchant provides any, some or all of the information in the location record **410**. Consider, for example, a case in which the display space management engine **402** determines the layout of the retail store **401** using measurements from the sensor(s) **420** when no customers are present in the retail store **401**. These measurements could detect or otherwise indicate the fixed structures in the retail store **401**, which are used to determine the layout. The display space management engine **402** could then transmit the layout to the merchant device **430**, which displays the layout to the retail merchant on a display screen. The retail merchant may be provided with options to define or delineate different regions in the layout of the retail store **401**. These regions could be defined at any level of granularity, such as one region per shelf, one region per shelving unit, or one region per aisle, for example. These regions are then transmitted to the display space management engine **402** and stored in the location record **410** for the retail store **401**. This may be considered a calibration step that occurs prior to measuring traffic densities in the retail store **401**.

[0192] In some implementations, traffic densities (from the traffic density record **414**) and recommended costs of display space (from the display space value record **416**) for the retail store **401** can be transmitted to the merchant device **430** for display to the retail merchant. If the retail merchant agrees with the recommended costs, then the retail merchant can then accept the recommended costs. Alternatively, the retail merchant can adjust the recommended costs, in which case the adjusted costs are transmitted to the display space management engine **402** and stored in the display space value record **416**. The retail merchant can use the traffic density data to help in their decision to accept or adjust the recommended costs.

[0193] Traffic densities (from the traffic density record **414**) and costs of display space (from the display space value record **416**) for the retail store **401** can also or instead be transmitted to the merchant device **440** for display to the

product merchant. Advantageously, the traffic densities can be free of PII, which allows the traffic densities to be viewable by any product merchants (i.e., product merchants do not need to have special permissions to view PII). Based on the traffic densities and costs of display space, the product merchant can purchase new display space, renew an existing lease on display space or bid against other merchants for display space, for example. After purchasing display space in a particular region of the retail store **401**, the product merchant can continue to receive and view traffic density information to determine if the region continues to meet their needs.

[0194] In addition to determining display space values, the display space management engine **402** can also be used for other applications, including but not limited to:

[0195] Optimizing retail store layouts by comparing popular and unpopular routes through the store, for example;

[0196] Identifying repeat and new customers based on biometric data; and

[0197] Measuring product shelf inventory and providing notifications when inventory is low.

[0198] In FIG. **4**, two merchant devices are shown by way of example. In general, more than two merchant devices may be in communication with the display space management engine **402**. As such, numerous different retail merchants and product merchants can communicate with the display space management engine **402** to manage and purchase display space in the retail store **401** and/or other locations.

[0199] An example implementation of sensors in a retail store is shown in FIG. **5**, which illustrates a layout of a retail store **500**. The retail store **500** includes: an entrance **502**; two cashier desks **504**, **506**; multiple shelving units **510**, **512**, **514**, **516**, **518**, **520**, **522**, **524**; two window displays **526**, **528**; and multiple sensors **530**, **532**, **534**, **536**, **538**, **540**, **542**, **544**, **546**, **548**, **550**, **552**, **554**, **556**, **558**, **560**, **562**, **564**, **566**, **568**, **570**. The retail store **500** generally has a grid-like architecture, but other retail stores may have different architectures such as herringbone, loop (or racetrack) and free-flow architectures, for example.

[0200] Each of the shelving units **510**, **512**, **514**, **516**, **518**, **520**, **522**, **524** are for holding and displaying products. The shelving units **510**, **512**, **514**, **516**, **518**, **520**, **522**, **524** include shelf space that can be sold or leased to product merchants in some implementations. FIG. **6** is a side-view of the shelving unit **516**, which illustrates three shelves that provide shelf space. Any, one, some or all of the other shelving units **510**, **512**, **514**, **518**, **520**, **522**, **524** could be similar to the shelving unit **516**.

[0201] The window displays **526**, **528** are areas in which advertisements can be placed and displayed to customers. As such, the window displays **526**, **528** provide advertising space that can be sold or leased to product merchants in some implementations.

[0202] The sensors **530**, **532**, **534**, **536**, **538**, **540**, **542**, **544**, **546**, **548**, **550**, **552**, **554**, **556**, **558**, **560**, **562**, **564**, **566**, **568**, **570** are provided to obtain measurements within the retail store **500**. The sensors **530**, **532**, **534**, **536**, **538**, **540**, **542**, **544**, **546**, **548**, **550**, **552**, **554**, **556**, **558**, **560**, **562**, **564**, **566**, **568**, **570** provide one example implementation of the sensor(s) **420** of FIG. **4**. As such, the retail store **500** could be an example of the retail store **401** of FIG. **4**.

[0203] The sensors **530**, **532**, **534**, **536**, **538**, **540**, **542**, **544**, **546**, **548**, **550**, **552**, **554**, **556**, **558**, **560**, **562**, **564**, **566**, **568**, **570** might all be of the same type or might be of multiple different types. Moreover, sensors that are of the same type might be configured in the same way or in different ways. For example, different radar sensors could be configured with the same parameters or could be independently configured with different parameters.

[0204] The sensors **530**, **532**, **534**, **536**, **538**, **540**, **542**, **544**, **546**, **548**, **570** are provided on or in the ceiling of the retail store **500**. By way of example, the sensor **536** is shown connected to the ceiling of the retail store **500** in FIG. **6**. However, one or more of the sensors **530**, **532**, **534**, **536**, **538**, **540**, **542**, **544**, **546**, **548**, **570** could instead be positioned behind a suitable ceiling tile of the retail store **500**. A suitable ceiling tile of the retail store **500** may, for example, be a ceiling tile formed of material(s) having dielectric properties selected so as to not interfere with sensors positioned behind the tile. Each of the sensors **530**, **532**, **534**, **536**, **538**, **540**, **542**, **544**, **546**, **548**, **570** can provide top-down spatial measurements of a respective area of the retail store **500**. These measurements may be consolidated and analysed to provide a 2D spatial map of the retail store **500**. The sensors **530**, **532**, **534**, **536**, **538**, **540**, **542**, **544**, **546**, **548**, **570** are positioned in the retail store **500** as follows:

[0205] The sensor **530** is positioned to acquire top-down spatial measurements of an area proximate the shelving unit **510**;

[0206] The sensor **532** is positioned to acquire top-down spatial measurements of an area proximate the shelving unit **512**;

[0207] The sensor **534** is positioned to acquire top-down spatial measurements of an area proximate the shelving unit **514**;

[0208] The sensor **536** is positioned to acquire top-down spatial measurements of an area proximate the shelving unit **516**;

[0209] The sensors **538**, **540** are positioned to acquire top-down spatial measurements of areas proximate the shelving unit **518**;

[0210] The sensors **542**, **544** are positioned to acquire top-down spatial measurements of areas proximate the shelving unit **520**;

[0211] The sensor **546** is positioned to acquire top-down spatial measurements of an area proximate the shelving unit **522**;

[0212] The sensor **548** is positioned to acquire top-down spatial measurements of an area proximate the shelving unit **524**; and

[0213] The sensor **570** is positioned to acquire top-down spatial measurements of an area proximate the entrance **502** and the window displays **526**, **528**.

[0214] Each of the sensors **550**, **552**, **554**, **556**, **558**, **560**, **562**, **564**, **566**, **568** are provided behind or within one of the shelving units **510**, **512**, **514**, **516**, **518**, **520**, **522**, **524** and measure the retail store **500** in the horizontal or lateral direction. By way of example, FIG. **6** shows the sensor **556** positioned behind the shelving unit **516**. The sensors **550**, **552**, **554**, **556**, **558**, **560**, **562**, **564**, **566**, **568** are positioned in the retail store **500** as follows:

[0215] The sensor **550** is positioned to acquire lateral spatial measurements of an area proximate the shelving unit **510**;

[0216] The sensor **552** is positioned to acquire lateral spatial measurements of an area proximate the shelving unit **512**;

[0217] The sensor **554** is positioned to acquire lateral spatial measurements of an area proximate the shelving unit **514**;

[0218] The sensor **556** is positioned to acquire lateral spatial measurements of an area proximate the shelving unit **516**;

[0219] The sensors **558**, **560** are positioned to acquire lateral spatial measurements of areas proximate the shelving unit **518**;

[0220] The sensors **562**, **564** are positioned to acquire lateral spatial measurements of areas proximate the shelving unit **520**;

[0221] The sensor **566** is positioned to acquire lateral spatial measurements of an area proximate the shelving unit **522**; and

[0222] The sensor **568** is positioned to acquire lateral spatial measurements of an area proximate the shelving unit **524**.

[0223] The sensors **530**, **532**, **534**, **536**, **538**, **540**, **542**, **544**, **546**, **548**, **570** measure the retail store **500** in the vertical direction, whereas the sensors **550**, **552**, **554**, **556**, **558**, **560**, **562**, **564**, **566**, **568** measure the retail store **500** in the lateral direction. Advantageously, these different sensor orientations may provide complimentary measurements of the retail store **500**. For example, there may be overlap in the areas measured by the sensors **536**, **556**, as each of the sensors **536**, **556** measures the area proximate the shelving unit **516**, but from a different perspective. Calibration of the sensors **536**, **556** could be performed to determine this overlap and account for the overlap during measurement analysis, which may improve the overall quality of the measurements. By way of example, exploiting the redundancy of the sensors **536**, **556** during measurement analysis could provide 3D spatial data points for the area proximate the shelving unit **516** and/or improve the accuracy of the measurements for the area proximate the shelving unit **516**.

[0224] The sensors **530**, **532**, **534**, **536**, **538**, **540**, **542**, **544**, **546**, **548**, **550**, **552**, **554**, **556**, **558**, **560**, **562**, **564**, **566**, **568**, **570** are in communication with a display space management engine (not shown), which receives measurements from the sensors and analyses the measurements to determine traffic densities and values of display space in the retail store **500**. This display space management engine may be similar to the display space management engine **402**, for example.

[0225] FIG. **7** is a flow diagram illustrating an example method **700** for evaluating display space. The method **700** will be described as being performed by the display space management engine associated with the retail store **500** of FIG. **5**. However, the method **700** is in no way limited to the retail store **500**.

[0226] In step **702**, a processor in the display space management engine obtains initial measurements from any one, some, or all of the sensors **530**, **532**, **534**, **536**, **538**, **540**, **542**, **544**, **546**, **548**, **550**, **552**, **554**, **556**, **558**, **560**, **562**, **564**, **566**, **568**, **570** when no persons (and optionally no products or shopping carts) are present in the retail store **500**. These initial measurements include initial spatial information that pertains to the fixed structures within the retail store **500**. The entrance **502**, the cashier desks **504**, **506**, the shelving units **510**, **512**, **514**, **516**, **518**, **520**, **522**, **524**, the window displays **526**, **528**, and the walls of the retail store **500** are all examples of fixed structures within the retail store **500**. The initial measurements for the retail store **500** could then be stored in a measurement record in the display space management engine.

[0227] In step **704**, a processor in the display space management engine determines a layout of the retail store **500** (such as the layout illustrated in FIG. **5**, for example) based on the initial measurements obtained in step **702**. To determine the layout, the processor may analyse the initial measurements using any method disclosed herein to determine the position and shape of objects within the retail store. Because the retail store **500** is empty of any customers, these objects can be interpreted as the fixed structures of the retail store. The layout, which could be determined in 2D or 3D, may indicate the size and position of the entrance **502**, the two cashier desks **504**, **506**, the shelving units **510**, **512**, **514**, **516**, **518**, **520**, **522**, **524**, the window displays **526**, **528**, and the walls of the retail store **500**. The layout of the retail store **500** may then be stored in a location record in the display space management engine.

[0228] In step **706**, a processor in the display space management engine obtains an indication of one or more boundaries for the regions of the retail store **500**. These boundaries delineate the different regions of the retail store **500**, which can tell the display space management engine how the retail store **500** should be divided for the purpose of determining traffic densities and the values of display space, for example. The boundaries for the retail store **500** can be stored in the location record in the display space management engine.

[0229] In some implementations, an indication of a boundary could be provided through a user interface by the retail merchant that owns the retail store **500**. This user interface may be part of the display space management engine or may be part of a merchant device that is remote from the display space management engine, for example. In some cases, the retail merchant can obtain and view the layout of the retail store **500** determined in step **704** and use this layout to define the boundaries between the different regions of the retail store **500**. For example, the layout shown in FIG. **5** could be displayed to the retail merchant though a user interface, along with an option to delineate different regions of the retail store **500** by indicating the virtual boundaries between these regions. Alternately or in addition, an algorithm stored by the display space management engine could automatically select the different regions of the retail store **500** based on the layout and one or more predefined rules or criteria. In an example, an algorithm could recommend boundaries for the different regions of the retail store **500** and present these recommended boundaries, along with a layout of the retail store **500**, to the retail merchant via a user interface. The merchant could then view, modify and/or accept the recommended boundaries.

[0230] In some implementations, traffic densities are used to aid in the determination of boundaries between different regions. For example, a layout of the retail store **500** could include an indication of traffic densities in various areas of the retail store **500**. These traffic densities can be determined based on measurements from the sensors **530**, **532**, **534**, **536**, **538**, **540**, **542**, **544**, **546**, **548**, **550**, **552**, **554**, **556**, **558**, **560**, **562**, **564**, **566**, **568**, **570** and may be presented as a heat map overlaid with the layout of the retail store **500**. A merchant and/or an algorithm could use the traffic density information to help define the boundaries between regions. For example,

boundaries may be defined where traffic densities in the retail store **500** cross pre-defined thresholds.

[0231] FIG. **8** illustrates a layout of the retail store **500** with multiple different regions **800**, **802**, **804**, **806**, **808**, **810**, **812**, **814**, **816**, **818**, **820**, **822**, **824**, **826**, **828**, **830**, **832**, **834** delineated by dashed lines. These dashed lines are examples of boundaries that may have been obtained in step **708** and are used to define the regions **800**, **802**, **804**, **806**, **808**, **810**, **812**, **814**, **816**, **818**, **820**, **822**, **824**, **826**, **828**, **830**, **832**, **834**. The regions **800**, **802**, **804**, **806**, **808**, **810**, **812**, **814**, **816**, **818**, **820**, **822**, **824**, **826**, **828**, **830**, **832**, **834** of the retail store **500** are defined as follows:

[0232] The region **800** includes the shelving unit **510** and the area proximate the shelving unit **510**. The region **800** is measured by at least the sensors **550**, **530**.

[0233] The region **802** includes the shelving unit **512** and the area proximate the shelving unit **512**. The region **802** is measured by at least the sensors **552**, **532**.

[0234] The region **804** includes the shelving unit **514** and the area proximate the shelving unit **514**. The region **804** is measured by at least the sensors **554**, **534**.

[0235] The shelving unit **516** and the area proximate the shelving unit **516** is divided between the regions **806**, **818**. The region **818** includes the end of the shelving unit **516** (which could also be considered the end of an aisle) proximate the entrance **502** and the cashier desks **504**, **506**. The region **806** includes the remainder of the shelving unit **516**. The region **818** may have been defined because the end of an aisle is known (through measurements, for example) or is expected to have a higher traffic density than the remainder of the aisle. The regions **806**, **818** are measured by at least the sensors **556**, **536**.

[0236] The shelving unit **518** and the area proximate the shelving unit **518** is divided between the regions **808**, **810**, **820**, **822**. The regions **808**, **820** include one side of the shelving unit **518** and the regions **810**, **822** include the other side of the shelving unit **518**. Further, the regions **820**, **822** include the end of the shelving unit **518** proximate the entrance **502** and the cashier desks **504**, **506**, and the regions **808**, **810** include the remainder of the shelving unit **518**. The regions **808**, **820** are measured by at least the sensors **558**, **538**, and the regions **810**, **822** are measured by at least the sensors **560**, **540**.

[0237] The shelving unit **520** and the area proximate the shelving unit **520** is divided between the regions **812**, **814**, **824**, **826**. The regions **812**, **824** include one side of the shelving unit **520** and the regions **814**, **826** include the other side of the shelving unit **520**. Further, the regions **824**, **826** include the end of the shelving unit **520** proximate the entrance **502** and the cashier desks **504**, **506**, and the regions **812**, **814** include the remainder of the shelving unit **520**. The regions **812**, **824** are measured by at least the sensors **562**, **542**, and the regions **814**, **826** are measured by at least the sensors **564**, **544**.

[0238] The shelving unit **522** and the area proximate the shelving unit **522** is divided between the regions **816**, **828**. The region **828** includes the end of the shelving unit **522** proximate the entrance **502** and the cashier desks **504**, **506**. The region **816** includes the remainder of the shelving unit **522**. The regions **816**, **828** are measured by at least the sensors **566**, **546**.

[0239] The region **830** includes the shelving unit **524** and the area proximate the shelving unit **524**. The region **830** is measured by at least the sensors **568**, **548**.

[0240] The region **832** includes the entrance **502** and the window displays **526**, **528**. The region **832** is measured by at least the sensor **570**.

[0241] While FIG. **8** only shows regions defined in 2D, regions can also be defined in 3D. FIG. **9** is a side-view of the shelving unit **516** and the regions **806**, **818**. The region **806** is divided into subregions **806***a*, **806***b*, **806***c* using dashed lines, wherein each subregion **806***a*, **806***b*, **806***c* corresponds to a different shelf of the shelving unit **516**. Similarly, the region **818** is divided into subregions **818***a*, **818***b*, **818***c* using dashed lines. The dashed lines shown in FIG. **9** are further examples of boundaries that may have been obtained in step **706** of the method **700**. The subregions **806***a*, **806***b*, **806***c*, **818***a*, **818***b*, **818***c* divide the display space in the shelving unit **516** in the vertical dimension. Any, one, some or all of the other regions **800**, **802**, **804**, **808**, **810**, **812**, **814**, **816**, **820**, **822**, **824**, **826**, **828**, **830**, **832**, **834** of the retail store **500** can include similar subregions that delineate display space in the vertical dimension. It should be noted that, as used herein, the terms "subregions" and "regions" are generally equivalent. As such, the subregions **806***a*, **806***b*, **806***c*, **818***a*, **818***b*, **818***c* can also be referred to as regions.

[0242] Referring again to FIG. **7**, step **708** includes a processor in the display space management engine obtaining measurements from at least one of the sensors **530**, **532**, **534**, **536**, **538**, **540**, **542**, **544**, **546**, **548**, **550**, **552**, **554**, **556**, **558**, **560**, **562**, **564**, **566**, **568**, **570**. These measurements include spatial information pertaining to at least one of the regions **800**, **802**, **804**, **806**, **808**, **810**, **812**, **814**, **816**, **818**, **820**, **822**, **824**, **826**, **828**, **830**, **832**, **834** of the retail store **500**. Unlike in step **702**, there may be customers in the retail store **500** during step **708**, and therefore the measurements could detect the presence, position, size, shape and/or velocity of customers. Objects such as shopping carts and products could also be measured.

[0243] Step **708** will now be described, by way of example, with reference to FIGS. **10** and **11**, which show measurements obtained for the regions **806**, **818**. It should be noted that measurements for any, one, some or all of the other regions **800**, **802**, **804**, **808**, **810**, **812**, **814**, **816**, **820**, **822**, **824**, **826**, **828**, **830**, **832**, **834** could be obtained in a similar manner.

[0244] FIG. **10** illustrates multiple spatial data point clusters **1000**, **1002**, **1004**, **1006**, **1008** in the regions **806**, **818** of the retail store **800**. These spatial data point clusters **1000**, **1002**, **1004**, **1006**, **1008** correspond to entities (such as customers and/or objects, for example) that have been measured by one or both of the sensors **556**, **536** at a particular point in time. By way of example, in the case that the sensors **556**, **536** are radar sensors, each of the spatial data point clusters **1000**, **1002**, **1004**, **1006**, **1008** represent multiple points in space that have reflected radio wave pulses emitted from the sensors **556**, **536**. In some implementations, the spatial data point clusters **1000**, **1002**, **1004**, **1006**, **1008** include 3D spatial data points.

[0245] Based on the spatial data point clusters **1000**, **1002**, **1004**, **1006**, **1008**, the position of the entities in the regions **806**, **818** can be determined. For example, it can be discerned that two entities are in the region **806**, and three entities are in the region **818**. The general size of the entities

can also be determined based on the spatial data point clusters **1000**, **1002**, **1004**, **1006**, **1008**. For example, all of the spatial data point clusters **1000**, **1004**, **1008** are generally the same size, indicating that the corresponding entities are also generally the same size. The entity corresponding to the spatial data point cluster **1006** is the smallest, and the entity corresponding to the spatial data point cluster **1002** is somewhere in between. The speed or velocity of the entities in the regions **806**, **818** might also be determined from the spatial data point clusters **1000**, **1002**, **1004**, **1006**, **1008**.

[0246] However, the shape of the entities in the regions **806**, **818** cannot be readily determined from the spatial data point clusters **1000**, **1002**, **1004**, **1006**, **1008**. The spatial data point clusters **1000**, **1002**, **1004**, **1006**, **1008** are generally circular, without any recognisable shape. Therefore, it cannot be readily determined what types of entities the spatial data point clusters **1000**, **1002**, **1004**, **1006**, **1008** correspond to. When collecting the spatial data point clusters **1000**, **1002**, **1004**, **1006**, **1008**, the sensors **556**, **536** could have been configured to achieve a large range (for example, sensing over the entire area of the regions **806**, **818**) and/or a high temporal resolution (for example, obtaining measurements in quick succession), which may have come at the cost of reducing the spatial resolution achieved by the sensors **556**, **536**. Accordingly, the spatial data point clusters **1000**, **1002**, **1004**, **1006**, **1008** are examples of coarse measurements that lack the spatial resolution to determine the shape of the entities.

[0247] In some implementations, step **708** includes obtaining multiple sets of measurements for an entity in a region, where each measurement is taken with a different sensor configuration. This could provide a broader range of information about the entity. For example, the spatial data point clusters **1000**, **1002**, **1004**, **1006**, **1008** could be a first set of measurements for entities in the regions **806**, **818**. One or both of the sensors **556**, **536** could then be adjusted to improve spatial resolution, and a second set of measurements could be obtained.

[0248] FIG. **11** illustrates a second set of spatial data point clusters **1100**, **1102**, **1104**, **1106**, **1108** in the regions **806**, **818** of the retail store **500**. The spatial data point clusters **1100**, **1102**, **1104**, **1106**, **1108** represent measurements obtained from the sensors **556**, **536** after adjusting at least one of the sensors **556**, **536** to improve spatial resolution. For example, the first set of spatial data point clusters **1000**, **1002**, **1004**, **1006**, **1008** could have been obtained by the sensors **556**, **536** scanning the entirety of the regions **806**, **818** at a relatively low resolution. After determining the positions of the entities in the regions **806**, **818** based on the spatial data point clusters **1000**, **1002**, **1004**, **1006**, **1008**, the spatial data point clusters **1100**, **1102**, **1104**, **1106**, **1108** could have been obtained by the sensors **556**, **536** scanning only the areas around the entities at a relatively high resolution.

[0249] Adjusting sensors can include, but is not limited to, adjusting the parameters of the sensors. Adjusting sensors can also or instead include switching between different sensors with different capabilities. For example, the spatial data point clusters **1000**, **1002**, **1004**, **1006**, **1008** could have been obtained from the sensor **556**, and the spatial data point clusters **1100**, **1102**, **1104**, **1106**, **1108** could have been obtained from the sensor **536**. Alternatively, either or both of the sensors **556**, **536** could actually be a collection of multiple sensors with different capabilities and that can be turned on or off depending on the situation.

[0250] As shown in FIG. **11**, the spatial data point clusters **1100**, **1102**, **1104**, **1106**, **1108** provide the shape of the entities in the regions **806**, **818**. For example, the spatial data point clusters **1100**, **1104**, **1108** each define an adult customer with a shopping cart. In some implementations, the shopping carts provided by the retail store **500** could be formed from material with high dielectric constants so that they are more easily detected by a radar sensor, for example. The spatial data point cluster **1102** defines an adult customer without a shopping cart, and the spatial data point cluster **1106** defines a child customer.

[0251] In some implementations, the spatial data point clusters **1100**, **1102**, **1104**, **1106**, **1108** have a sufficient spatial resolution to outline the anatomical features of the customers. Therefore, some actions of the customers in the regions **806**, **818** could be detected based, in part, on the spatial data point clusters **1100**, **1102**, **1104**, **1106**, **1108**. In an example, the spatial data point cluster **1102** could show the corresponding customer reaching towards the subregion **806***b* and interacting with a product.

[0252] Referring again to step **708** of FIG. **7**, measurements could be obtained continuously or intermittently over a period of time. For example, the spatial data point clusters **1000**, **1002**, **1004**, **1006**, **1008**, **1100**, **1102**, **1104**, **1106**, **1108** could be measurements of the regions **806**, **818** that are taken at one-point in time. Further measurements could then be taken at fixed intervals thereafter. As such, the measurements obtained in step **708** could include measurements obtained over a period of hours, day, weeks, months or years, for example. Any, some or all of the measurements obtained in step **708** can be stored in a measurement record in the display space management engine.

[0253] In step **710**, a processor in the display space management engine determines, based on the measurements obtained in step **708**, a traffic density associated with at least one of the regions **800**, **802**, **804**, **806**, **808**, **810**, **812**, **814**, **816**, **818**, **820**, **822**, **824**, **826**, **828**, **830**, **832**, **834** of the retail store **500**. Furthermore, traffic densities can be determined for each subregion in the regions **800**, **802**, **804**, **806**, **808**, **810**, **812**, **814**, **816**, **818**, **820**, **822**, **824**, **826**, **828**, **830**, **832**, **834**, including the subregions **806***a*, **806***b*, **806***c*, **818***a*, **818***b*, **818***c*. For example, customer actions could be used to determine which of the subregions **806***a*, **806***b*, **806***c* a customer is interacting with when standing in the region **806**. Any, some or all of the traffic densities obtained in step **710** can be stored in a traffic density record in the display space management engine.

[0254] A traffic density could be determined in step **710** using any method disclosed herein. For a given region of the retail store **500**, step **710** may include (but is not limited to) any, one, some or all of the following operations:

- **[0255]** determining a number of persons that enter the region over a period of time;
- **[0256]** determining an average time that a person spends in the region;
- **[0257]** determining a number of shopping carts that enter the region over the period of time; and
- **[0258]** determining a number of persons that interact with products in the region over the period of time.

[0259] In some cases, a traffic density is determined based on the layout determined in step **704**. Using the layout, the processor can compare the measurements obtained in step **708** to the position of the fixed structures in the retail store **500**. Any measurements that correspond to the fixed struc-

tures in the retail store **500** can then be disregarded. Therefore, the traffic densities determined in step **710** can be limited to the customers, shopping carts and optionally products in the retail store **500**.

[0260] In some implementations, step **710** can include tracking the movement of customers through the retail store **500**. The typical paths taken by customers in the retail store **500** may be used to help determine the traffic densities in the retail store **500**. The paths can also indicate the desirability of some products in the retail store **500**. Customers may travel a further distance and spend a longer time looking for more desirable products. By way of example, staple grocery store products such as eggs and milk can be displayed in a region relatively far from the entrance of the grocery store because customers will often travel the length of the store to reach these staple products. In this example, the route taken by customers can be determined in step **710**, and the traffic densities for regions within this route may be determined accordingly. Further, this information can help a merchant determine where to place their staple products to increase the portion of the retail store that customers will traverse to reach the staple products.

[0261] In step **712**, a processor in the display space management engine determines, based on the traffic density (or densities) determined in step **710**, a value associated with displaying products in at least one of the regions **800**, **802**, **804**, **806**, **808**, **810**, **812**, **814**, **816**, **818**, **820**, **822**, **824**, **826**, **828**, **830**, **832**, **834** of the retail store **500**. Values of display space can also be determined for subregions of the regions **800**, **802**, **804**, **806**, **808**, **810**, **812**, **814**, **816**, **818**, **820**, **822**, **824**, **826**, **828**, **830**, **832**, **834**, including the subregions **806***a*, **806***b*, **806***c*, **818***a*, **818***b*, **818***c*. Accordingly, each of the different regions and subregions in the retail store **500** can have different values of display space.

[0262] In some implementations, a cost of purchasing or leasing shelf space in the shelving units **510**, **512**, **514**, **516**, **518**, **520**, **522**, **524** is determined in step **712**. Furthermore, the cost of purchasing or leasing advertising space in the window displays **526**, **528** can be determined in step **712**. Any, some or all of the values of display space determined in step **712** can be stored in a display space value record in the display space management engine.

[0263] Step **712** could be performed using any method disclosed herein. In some implementations, step **712** includes comparing the traffic densities of any two or more of the regions **800**, **802**, **804**, **806**, **808**, **810**, **812**, **814**, **816**, **818**, **820**, **822**, **824**, **826**, **828**, **830**, **832**, **834**, and determining the value of display space in these regions based on the comparison. In other implementations, multiple traffic density thresholds are defined and values of display space in a region are determined based on the traffic density thresholds that are exceeded by the region.

[0264] In step **714**, a processor in the display space management engine can output the values of display space determined in step **712** for display on a user interface. The display space management engine can also (or instead) output the traffic densities determined in step **710** for display on the user interface. The user interface may be part of the display space management engine or part of a merchant device that is associated with a product merchant or a retail merchant, for example. As such, step **714** can include transmitting values of display space and/or traffic densities to a merchant device. To obtain the values of display space and/or the traffic densities, the processor may query the traffic density record and/or the display space value record in the display space management engine.

[0265] A retail merchant may use the information output in step **714** to decide how to price the display space in the retail store **500**. Further, the information could allow the retail merchant to improve the layout of the retail store **500** to increase traffic densities, values of display space and/or overall sales in the retail store **500**. Improving the layout of the retail store **500** could include moving the fixed structures within the retail store **500** and/or improving the organization of products in the retail store **500**, for example. In some implementations, an improved layout may be generated by one or more models stored in the display space management engine. The retail merchant that owns the retail store **500** may also sell products within the retail store **500**, and therefore the retail merchant could use the information provided in step **714** to decide where to display their products.

[0266] A product merchant may use the information output in step **714** to determine whether to purchase or lease display space in the retail store **500**, and if so which region of the retail store **500** to purchase display space in. In some cases, a model stored in the display space management engine could recommend certain regions of the retail store **500** to the product merchant based on the merchant's needs and/or to help increase the merchant's sales. If the product merchant already owns or rents display space in the retail store **500**, then the product merchant could use the information output in step **714** to determine or confirm that the display space is meeting their needs. For example, a product merchant might want to confirm that the region where their products are displayed receives a certain number of customers per day.

[0267] For any region of the retail store **500**, a value of display space and a traffic density could be displayed with a representation of the region in step **714**. For example, values of display space and traffic densities could be overlaid with, or displayed side-by-side with, a layout of the retail store **500**. FIG. **12** illustrates content **1200** showing traffic densities and values of display space overlaid with a layout of the retail store **500**. The content **1200** is an example of information that can be generated by the display space management engine and output for display on a user interface in step **714**. The content **1200** can allow a merchant (or other user) to visualize traffic densities and values of display space within the retail store **500**. The sensors **530**, **532**, **534**, **536**, **538**, **540**, **542**, **544**, **546**, **548**, **550**, **552**, **554**, **556**, **558**, **560**, **562**, **564**, **566**, **568**, **570** are not shown in FIG. **12** to avoid congestion of the figure.

[0268] FIG. **12** shows an average value of traffic density for each region of the retail store **500**, as determined in step **710**. The average traffic densities are provided in terms of customers per day (cpd), which represents the measured number of customers that interact with products in a particular region in an average day. This is only one example metric for traffic density, and other metrics could also or instead be presented. In general, a merchant (or other user) that is viewing the content **1200** could select one or more metrics for traffic density that can be displayed with the layout of the retail store **500**.

[0269] FIG. **12** also shows an average value of display space for each region of the retail store **500**, as determined in step **712**. For the regions that include shelving units, the values of display space are provided in terms of a cost of

leasing one square meter of shelving space for a week. For region **832**, which includes the window displays **526**, **528**, the value of display space is provided in terms of leasing one window display for a week.

[0270] Average traffic densities and average values of display space are provided in the content **1200** because at least some regions of the retail store **500** can contain multiple subregions. Accordingly, each of these subregions can have a respective value of traffic density and value of display space. For a given region, the average traffic densities and average values of display space shown in the content **1200** represent averages of the traffic densities and values of display space for the different subregions in the region.

[0271] FIG. **13** illustrates content **1300** showing traffic densities and values of display space overlaid with the shelving unit **516**. The content **1300** includes a respective traffic density (in terms of cpd) and a respective value of display space (in terms of a cost of leasing one square meter of shelving space for a week) for each of the subregions **806***a*, **806***b*, **806***c*, **818***a*, **818***b*, **818***c*. FIG. **13** illustrates traffic densities and values of display space that have been determined in 3D based on 3D spatial data points, for example. In some implementations, the content **1300** is transmitted to, and displayed on, a user interface after a merchant selects the shelving unit **516** in the content **1200** via a user interface.

[0272] It should be noted that FIGS. **12** and **13** provide only one way to characterize and present traffic densities and display space values, and many others are contemplated. For example, traffic densities and/or display space values could instead be presented as a heat map overlaid with a layout of the retail store **500**. In some implementations, other information could also be presented with a layout of the retail store **500**, an example of which is the sales conversion percentage for a given product on a shelf.

[0273] Steps **708**, **710**, **712**, **714** can be repeated several times, which is shown using the arrow from step **714** to step **708** in FIG. **7**. As new measurements become available, traffic densities and values of display space can be updated to reflect the new measurements. The new measurements can detect changes in customer patterns, changes to the layout of the retail store **500** and changes to the products displayed in the retail store **500**. Accordingly, repeating steps **708**, **710**, **712**, **714** can provide merchants with traffic densities and display space values based on the most relevant information available.

[0274] In step **716**, a processor in the display management engine obtains a modification to one or more of the values of display space output in step **714**. For example, after viewing the traffic densities and values of display space for the retail store **500**, the retail merchant that owns the retail store **500** could choose to modify one or more of the values of display space. In some cases, this modification is generated by a user interface on a merchant device and is transmitted to the display space management engine. Based on the modification obtained in step **716**, a processor in the display space evaluation engine generates one or more modified values of display space in step **718**. In some implementations, step **718** includes modifying the values of display space stored in a display space value record. The modified values of display space can then be outputted for display on a user interface. For example, the content **1200**, **1300** can be updated to reflect the modified values of display space.

CONCLUSION

[0275] Although the present invention has been described with reference to specific features and embodiments thereof, various modifications and combinations can be made thereto without departing from the invention. The description and drawings are, accordingly, to be regarded simply as an illustration of some embodiments of the invention as defined by the appended claims, and are contemplated to cover any and all modifications, variations, combinations or equivalents that fall within the scope of the present invention. Therefore, although the present invention and its advantages have been described in detail, various changes, substitutions and alterations can be made herein without departing from the invention as defined by the appended claims. Moreover, the scope of the present application is not intended to be limited to the particular embodiments of the process, machine, manufacture, composition of matter, means, methods and steps described in the specification. As one of ordinary skill in the art will readily appreciate from the disclosure of the present invention, processes, machines, manufacture, compositions of matter, means, methods, or steps, presently existing or later to be developed, that perform substantially the same function or achieve substantially the same result as the corresponding embodiments described herein may be utilized according to the present invention. Accordingly, the appended claims are intended to include within their scope such processes, machines, manufacture, compositions of matter, means, methods, or steps.

[0276] Moreover, any module, component, or device exemplified herein that executes instructions may include or otherwise have access to a non-transitory computer/processor readable storage medium or media for storage of information, such as computer/processor readable instructions, data structures, program modules, and/or other data. A non-exhaustive list of examples of non-transitory computer/processor readable storage media includes magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices, optical disks such as compact disc read-only memory (CD-ROM), digital video discs or digital versatile disc (DVDs), Blu-ray Disc™, or other optical storage, volatile and non-volatile, removable and non-removable media implemented in any method or technology, random-access memory (RAM), read-only memory (ROM), electrically erasable programmable read-only memory (EEPROM), flash memory or other memory technology. Any such non-transitory computer/processor storage media may be part of a device or accessible or connectable thereto. Any application or module herein described may be implemented using computer/processor readable/executable instructions that may be stored or otherwise held by such non-transitory computer/processor readable storage media.

1. A computer-implemented method comprising:

obtaining measurements from at least one sensor, the measurements comprising spatial information pertaining to a region of a retail store;

determining, based on the measurements, a traffic density associated with the region; and

determining, based on the traffic density, a value associated with displaying products in the region.

2. The computer-implemented method of claim **1**, wherein:

the region is a first region, the traffic density is a first traffic density and the value is a first value;

the measurements comprise spatial information pertaining to a plurality of regions of the retail store, the plurality of regions including the first region and a second region; and

the computer-implemented method further comprises:

determining, based on the measurements, a second traffic density associated with the second region.

3. The computer-implemented method of claim **2**, wherein determining the first value comprises comparing the first traffic density to the second traffic density.

4. The computer-implemented method of claim **2**, further comprising:

determining, based on the second traffic density, a second value associated with displaying products in the second region.

5. The computer-implemented method of claim **1**, wherein determining the traffic density comprises at least one of:

determining a number of persons that enter the region over a period of time;

determining an average time that a person spends in the region;

determining a number of shopping carts that enter the region over the period of time; and

determining a number of persons that interact with products in the region over the period of time.

6. The computer-implemented method of claim **1**, wherein obtaining the measurements from the at least one sensor comprises:

obtaining, from the at least one sensor, a first measurement of an entity that is in the region;

adjusting the at least one sensor based on the first measurement; and

after adjusting the at least one sensor, obtaining a second measurement of the entity.

7. The computer-implemented method of claim **6**, wherein adjusting the at least one sensor comprises adjusting a resolution of the at least one sensor.

8. The computer-implemented method of claim **1**, further comprising:

prior to obtaining the measurements, obtaining initial measurements from the at least one sensor when no persons are present in the region of the retail store, the initial measurements comprising initial spatial information pertaining to fixed structures within the region,

wherein determining the traffic density associated with the region is further based on the initial measurements.

9. The computer-implemented method of claim **1**, wherein the spatial information comprises three-dimensional information.

10. The computer-implemented method of claim **1**, wherein the spatial information comprises at least one of a position, a shape and a speed of an entity in the region.

11. The computer-implemented method of claim **1**, wherein obtaining the measurements comprises obtaining radio wave measurements.

12. The computer-implemented method of claim **1**, further comprising:

outputting the value for display on a user interface with a representation of the region of the retail store.

13. The computer-implemented method of claim **1**, further comprising:

obtaining, from a user interface, a modification to the value; and

generating, based on the modification, a modified value associated with displaying products in the region.

14. The computer-implemented method of claim **1**, further comprising:

obtaining, from a user interface, an indication of a boundary of the region of the retail store.

15. A system comprising:

memory store measurements obtained from at least one sensor, the measurements comprising spatial information pertaining to a region of a retail store; and

at least one processor to:

determine, based on the measurements, a traffic density associated with the region; and

determine, based on the traffic density, a value associated with displaying products in the region.

16. The system of claim **15**, wherein:

the region is a first region, the traffic density is a first traffic density and the value is a first value;

the measurements comprise spatial information pertaining to a plurality of regions of the retail store, the plurality of regions including the first region and a second region; and

the at least one processor is further to determine, based on the measurements, a second traffic density associated with the second region.

17. The system of claim **16**, wherein the first value is determined based on a comparison of the first traffic density to the second traffic density.

18. The system of claim **16**, wherein the at least one processor is further to determine, based on the second traffic density, a second value associated with displaying products in the second region.

19. The system of claim **15**, wherein the traffic density comprises at least one of:

a number of persons that enter the region over a period of time;

an average time that a person spends in the region;

a number of shopping carts that enter the region over the period of time; and

a number of persons that interact with products in the region over the period of time.

20. The system of claim **15**, wherein the at least one processor is further to:

obtain, from the at least one sensor, a first measurement of an entity that is in the region;

adjust the at least one sensor based on the first measurement; and

after adjusting the at least one sensor, obtain a second measurement of the entity, wherein the measurements comprise the first measurement and the second measurement.

21. The system of claim **20**, wherein a resolution of the at least one sensor is adjusted.

22. The system of claim **15**, wherein:

the memory further stores initial measurements obtained from the at least one sensor when no persons are present in the region of the retail store, the initial measurements comprising initial spatial information pertaining to fixed structures within the region, and

wherein the traffic density associated with the region is determined based on the initial measurements.

23. The system of claim **15**, wherein the spatial information comprises three-dimensional information.

24. The system of claim **15**, wherein the spatial information comprises at least one of a position, a shape and a speed of an entity in the region.

25. The system of claim **15**, wherein the measurements comprise radio wave measurements.

26. The system of claim **15**, wherein the at least one processor is further to:

output the value for display on a user interface with a representation of the region of the retail store.

27. The system of claim **15**, wherein the at least one processor is further to:

obtain, from a user interface, a modification to the value; and

generate, based on the modification, a modified value associated with displaying products in the region.

28. The system of claim **15**, wherein the at least one processor is further to:

obtain, from a user interface, an indication of a boundary of the region of the retail store.

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