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(54) **SECURITY MANAGEMENT ON A MOBILE DEVICE**

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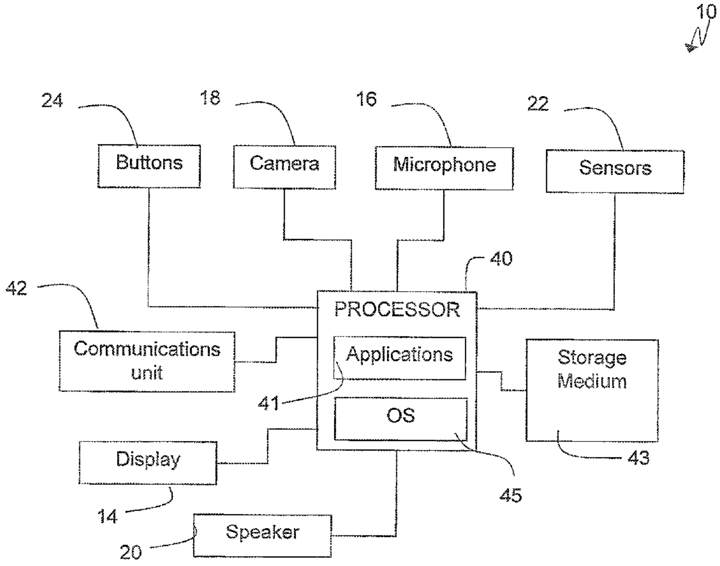
(57) **ABSTRACT**

Example mobile devices disclosed herein include a camera, memory including computer-executable instructions, and a processor to execute the instructions to at least associate a location of the mobile device with picture data obtained with the camera. The processor is also to assign a first data tag to the picture data when the location of the mobile device corresponds to a first area, the first data tag to identify a first security level for the picture data, or assign a second data tag to the picture data when the location of the mobile device does not correspond to the first area, the second data tag to identify a second security level for the picture data. The processor is further to determine whether to permit an application to access the picture data based on whether the first data tag or the second data tag is assigned to the picture data.

20 Claims, 4 Drawing Sheets



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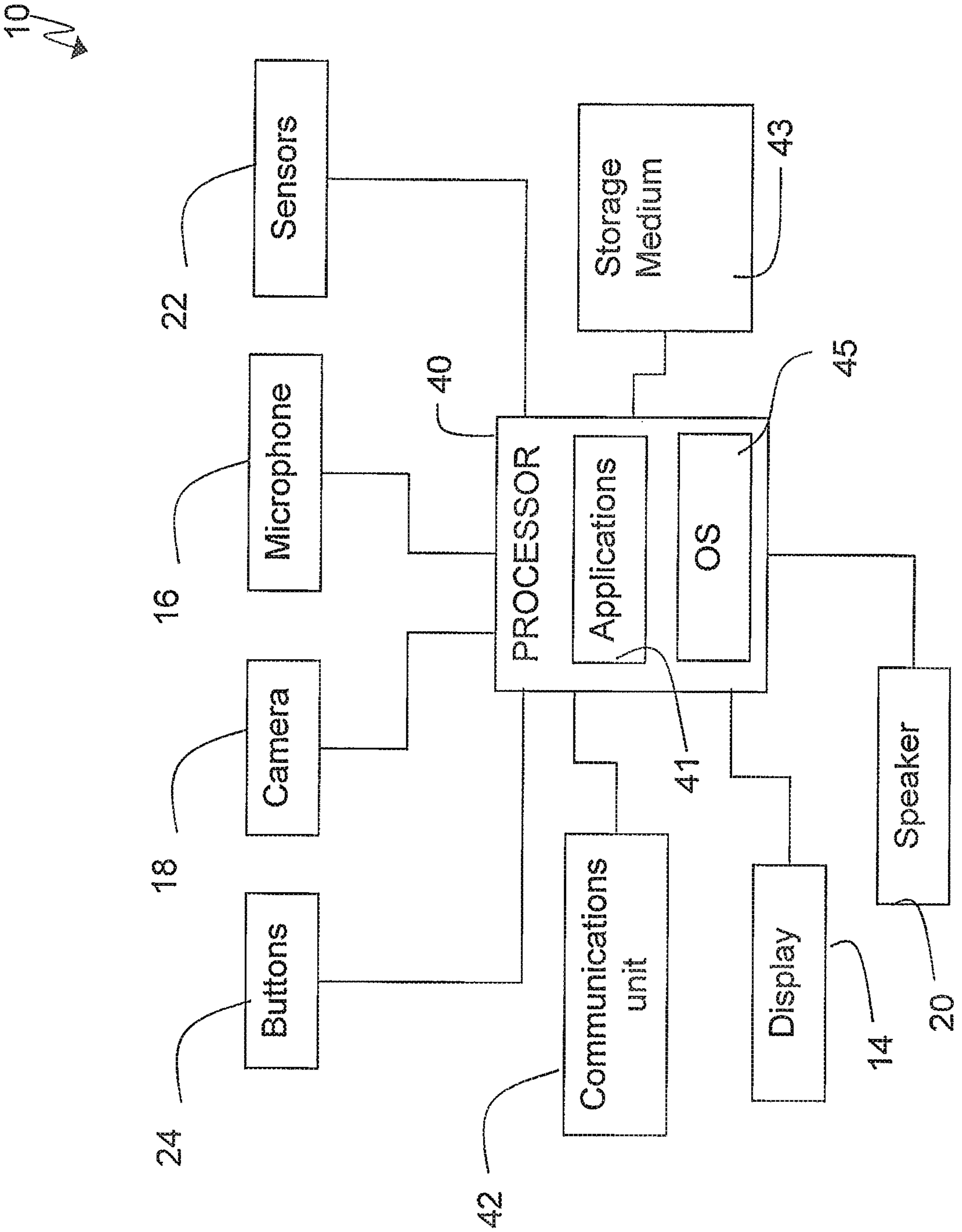

10
Sensors
22
Microphone
16
Camera
18
Buttons
24
Storage Medium
43
PROCESSOR
40
Applications
41
OS
45
Communications unit
42
Display
14
Speaker
20

FIG. 1

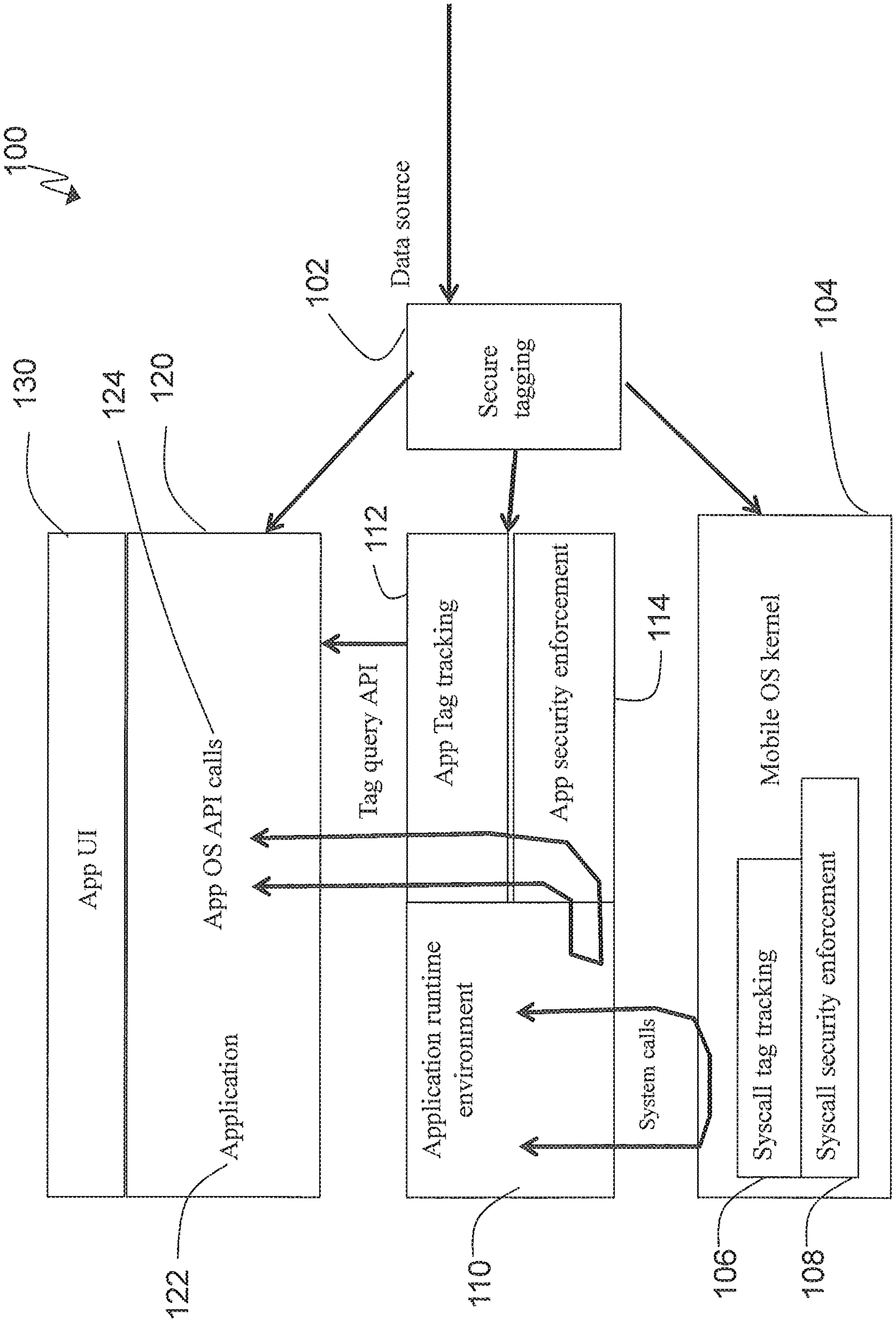
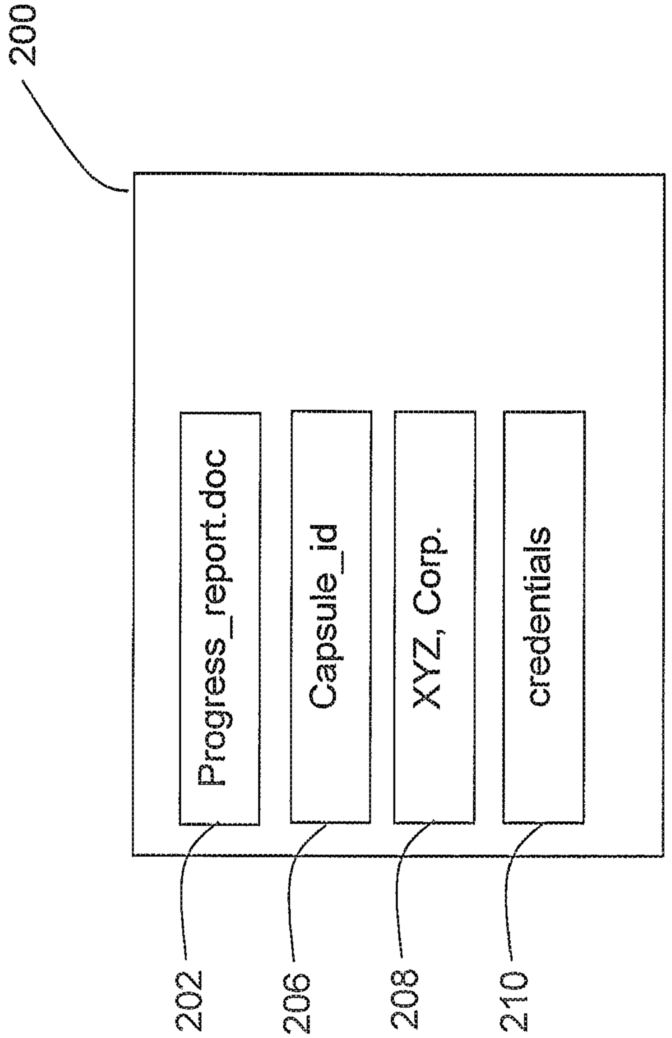

100
Data source
102
Secure tagging
130
124
120
112
104
App UI
App OS API calls
Application
Tag query API
App Tag tracking
App security enforcement
114
Mobile OS kernel
Application runtime environment
System calls
Syscall tag tracking
Syscall security enforcement
122
110
106
108

FIG. 2

FIG. 3


200
Progress_report.doc
Capsule_id
XYZ, Corp.
credentials
202
206
208
210

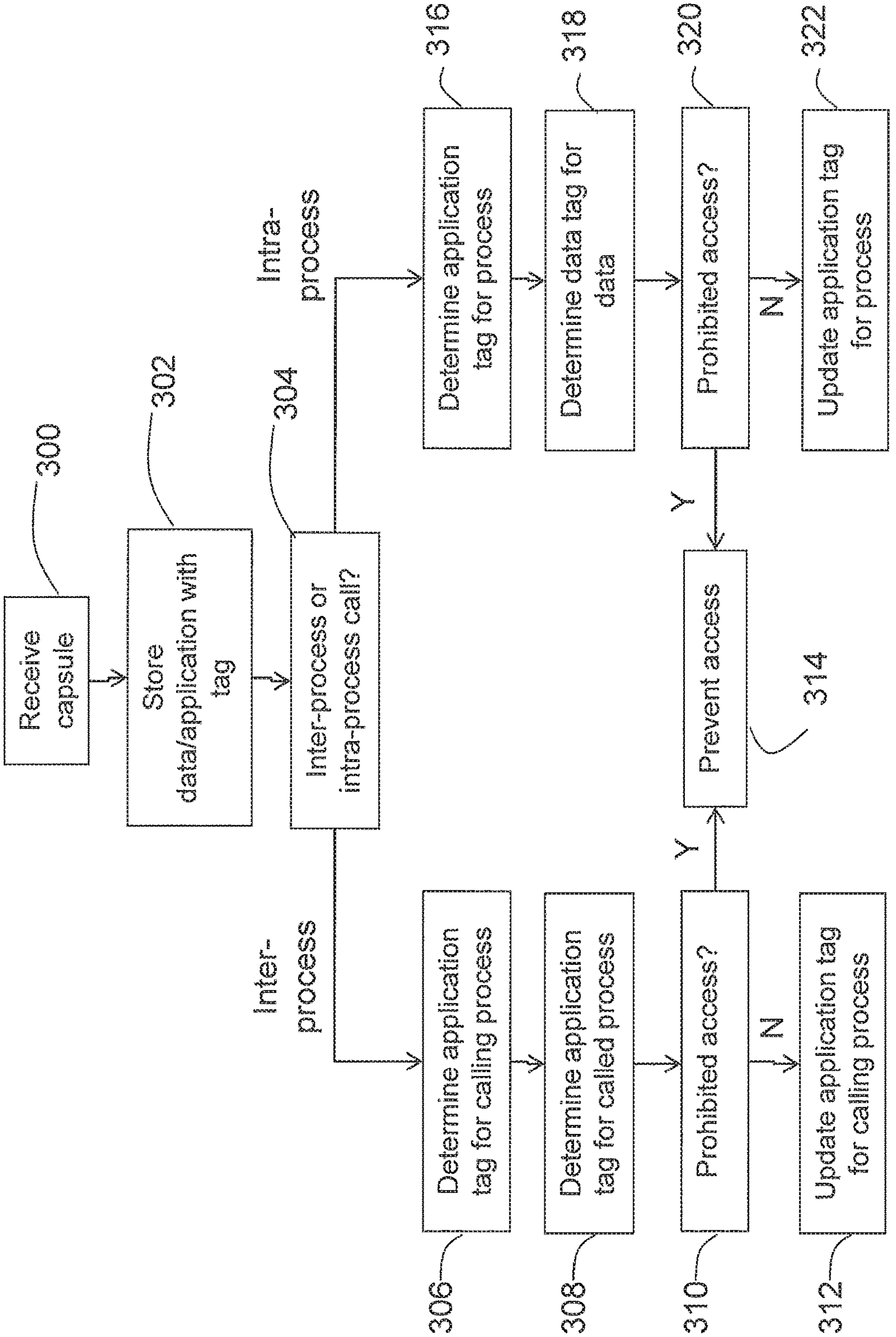

Receive capsule
300
Store data/application with tag
302
Inter-process or intra-process call?
304
Inter-process
Determine application tag for calling process
306
Determine application tag for called process
308
Prohibited access?
310
N
Update application tag for calling process
312
Y
Prevent access
314
Intra-process
Determine application tag for process
316
Determine data tag for data
318
Prohibited access?
320
Y
N
Update application tag for process
322

FIG. 4

SECURITY MANAGEMENT ON A MOBILE DEVICE

RELATED APPLICATIONS

This application is a continuation and claims benefit of U.S. patent application Ser. No. 18/192,295, filed Mar. 29, 2023, which is a continuation of U.S. patent application Ser. No. 17/025,741, filed Sep. 18, 2020 (now U.S. Pat. No. 11,641,581), which is a continuation of U.S. patent application Ser. No. 16/119,427, filed Aug. 31, 2018 (now U.S. Pat. No. 10,820,204), which is a continuation of U.S. patent application Ser. No. 14/089,942, filed on Nov. 26, 2013 (now U.S. Pat. No. 10,070,315). All sections of the aforementioned applications and patents are incorporated herein by reference in their entirety.

BACKGROUND

The present disclosure relates generally to security management on mobile devices. Mobile devices, such as smartphone and tablets, are quickly becoming the dominant platform over which cloud services and content are consumed. For example, many workplaces now allow employees to use their own personal mobile devices to access employer resources (e.g., bring your own device or BYOD). One challenge faced by users of mobile devices is preventing the co-mingling of personal information and workplace information.

One exemplary existing solution allows a user to create separate personal and workplace environments on the same device. The enterprise data and applications are hosted in the cloud, and consumed from the mobile device using a thin-client solution. This architecture results in duplication for the user. Duplication also occurs when virtual machines running on the phone or other sandboxed environments on are used. For example, the user may run different email applications for the personal environment and for the workplace environment, different applications for reading/modifying content (PDF files, etc.), different settings applications, etc. Furthermore, the applications made accessible in the workplace environment have to be individually certified to ensure that they do not leak sensitive data to unauthorized parties.

BRIEF SUMMARY

Exemplary embodiments include a method for managing security levels on a mobile device, the method including receiving a capsule including first data; assigning a first data tag to the capsule, the first data tag identifying a security level for the first data; storing the capsule on the mobile device; executing a process on the mobile device, the process associated with an application tag; allowing the process to access the first data when the application tag matches the first data tag, the process for generating second data in response to the first data.

Other exemplary embodiments include an apparatus including a processor; and memory comprising computer-executable instructions that, when executed by the processor, cause the processor to perform operations, the operations including receiving a capsule including first data; assigning a first data tag to the capsule, the first data tag identifying a security level for the first data; storing the capsule on the mobile device; executing a process on the mobile device, the process associated with an application tag; allowing the process to access the first data when the application tag matches the first data tag, the process for generating second data in response to the first data.

Other exemplary embodiments include a computer program product, tangibly embodied on a non-transitory computer readable medium, for managing security levels on a mobile device, the computer program product including instructions that, when executed by a processor, cause the processor to perform operations including receiving a capsule including first data; assigning a first data tag to the capsule, the first data tag identifying a security level for the first data; storing the capsule on the mobile device; executing a process on the mobile device, the process associated with an application tag; allowing the process to access the first data when the application tag matches the first data tag, the process for generating second data in response to the first data.

Other systems, methods, and/or computer program products according to embodiments will be or become apparent to one with skill in the art upon review of the following drawings and detailed description. It is intended that all such additional systems, methods, and/or computer program products be included within this description, be within the scope of the exemplary embodiments, and be protected by the accompanying claims.

BRIEF DESCRIPTION OF EXEMPLARY EMBODIMENTS

Referring now to the drawings wherein like elements are numbered alike in the several FIGURES:

FIG. **1** depicts a mobile device in an exemplary embodiment;

FIG. **2** depicts an architecture for security management in an exemplary embodiment;

FIG. **3** depicts a capsule in an exemplary embodiment; and

FIG. **4** is a flowchart of a process for security management in an exemplary embodiment.

The detailed description explains the exemplary embodiments, together with advantages and features, by way of example with reference to the drawings.

DETAILED DESCRIPTION OF DRAWINGS

FIG. **1** illustrates a mobile device **10** according to an exemplary embodiment. Mobile device **10** may be a phone, tablet, personal digital assistant, etc., equipped with communications components (e.g., cellular, wireless LAN, NFC, Bluetooth, USB) for communicating over wireless or wired communications mediums. Mobile device **10** includes a display **14** such as an organic light emitting diode (OLED) display or liquid crystal diode (LCD) display, a microphone **16** used for voice communications and for receiving spoken commands from a user, a camera **18**, a speaker **20** that provides audio output to the user, and one or more buttons **24** for controlling the device. Buttons **24** may be permanent components built into a housing or may be virtual buttons, presented on display **14**, activated by touching display **14**. One or more sensors **22** may be used to sense various parameters such as location (e.g., GPS receiver), etc.

A processor **40** controls operation of mobile device **10**. Processor **40** may be implemented using a general-purpose microprocessor executing a computer program stored in a computer readable storage medium **43** to execute the processes described herein. Processor **40** may include memory (e.g., RAM) for loading programs for execution. Storage medium **43** provides storage accessible by applications **41**.

Storage medium **43** provides for storage of capsules defining security levels associated with data and applications on the mobile device **10**. Processor **40** executes an operating system **45** and a number of applications **41**, such as an email application, a calendar application, etc.

Processor **40** is also coupled to a communications unit **42** that handles communications between the mobile device **10** and other devices, such as cellular phone calls, NFC communications, Bluetooth, etc. The communications unit **42** is configured to communicate over a wireless network and may also include a port (e.g., USB) for wired connections.

FIG. **2** depicts architecture **100** for security management on mobile device **10** in an exemplary embodiment. As data is received from a data source, a secure tagging function **102** assigns a tag to the data. The data source may be external to the mobile device (e.g., retrieved from a server) or generated at the mobile device (e.g., a photo taken by the camera). Prior to any data being stored, the data is assigned a data tag that is used control access to the data and control propagation of the data, both internal and external to the mobile device **10**. Tags assigned to data may be used to prevent data with different tags from being mixed. As data is accessed and processed, the tag associated with that data may change. Data tags are also propagated, i.e., if new data is produced by the processing of tagged data, it inherits the data tag of that processed data. This ensures that data that may be derived from tagged data also stays within the same security-perimeter. Applications may be assigned an application tag based on what operations are being performed, what data is accessed, and/or the environment where the mobile device is operating. Managed applications (e.g., those that run in an instrumented runtime environment) may also process data having multiple tags as long as the managed applications do not mix data having different tags or violate security policies associated with the tags.

The secure tagging function **102** may assign a tag to the data based on a capsule that incorporates the data and a data tag. The capsule may be considered similar to an encrypted folder containing the data and other fields and defines a micro-security perimeter. FIG. **3** shows an exemplary capsule **200** having data **202** (e.g., a document from the workplace), a unique capsule identifier **206** and an owner **208**. It is understood that other fields may be incorporated into the capsule **200**. For example, if user credentials **210** are needed to access the data (e.g., a pin, user login and password), these fields may be incorporated in capsule **200** as well. When the tagged credentials are used to access an external resource (e.g., an email server), any data that comes back (e.g., an email), will be tagged with the same tag, so as to ensure that the retrieved data is in the same security perimeter as the credentials provided in the capsule. Capsule **200** may include a security/mixing policy that requires the user to enter a passcode when any data in the capsule is accessed by an application. Such a policy may also require the data in the capsule **200** to be decrypted only after the passcode is entered, is to prevent data access when a device is lost, stolen, etc.

Referring back to FIG. **2**, secure tagging function **102** receives capsule **200** and associates a data tag with data **202**, prior to storing capsule **200** on the mobile device (e.g., on storage medium **43**). It is understood that instead of data **202**, capsule **200** may include an application for installation on mobile device **10**. In this case, an application tag is assigned to the application contained in the capsule **200**. It is noted that the data tag and/or application tag may be neutral, for example, not initially associated with a particular environment (e.g., personal or workplace).

Architecture **100** includes an operating system level **104**. Operating system level **104** implements a system call tag tracking application **106** that tracks data tags and application tags between processes executing on mobile device **10**. Operating system level **104** also implements a system call security enforcement application **108** that allows or prevents operations based on the data tags and application tags. The system call tag tracking application **106** and system call security enforcement application **108** assign data tags and application tags during interaction between processes to prevent mixing of data tags and/or application tags of different types, and to propagate the appropriate data tags and/or application tags upon execution of processes. Operating system level **104** may be referred to as managing security between processes or inter-process.

Architecture **100** includes an application runtime level **110**. Application runtime level **110** provides a runtime environment (e.g., Android Dalvik) for applications executing on the mobile device **10**. Application runtime level **110** implements an application tag tracking application **112** that tracks data tags and application tags within a process executing on the mobile device **10**. Application runtime level **110** also implements an application security enforcement application **112** that allows or prevents operations based on the data tags and application tags. The application tag tracking application **112** and application security enforcement application **114** assign data tags and application tags within a process to prevent mixing of data tags and/or application tags of different types, and propagate the appropriate data tags and/or application tags upon execution of a process. Application runtime level **110** may be referred to as managing security within a process or intra-process.

An application program interface level **120** provides a mechanism for an application **122** executing on mobile device **10** to generate an application program interface call **124** to the operating system level **104** to determine a data tag and/or an application tag for data and/or an application that the executing application **122** is accessing. The application **122** can then reflect the nature of the data tag and/or application tag in an application user interface **130**. For example, a document reader application accesses a document, and generates an application program interface call **124** to the operating system level **104** to determine a data tag for the document. The document reader interface can be displayed in response to the data tag (e.g., yellow for workplace document, green for personal document). Similarly, an email application may present personal emails in a first color and workplace emails in a second color.

FIG. **4** is flowchart of processing performed by mobile device **10** to manage security in an exemplary embodiment. The process begins at **300** where capsules **200** are received at the secure tagging function **102**. As described above with reference to FIG. **2**, capsules **200** are stored on mobile device **10** along with the appropriate data tag and/or application tag at **302**. At **304**, an application executing on mobile device **10** initiates a call. If the call is an inter-process call, flow proceeds to **306**. At **306**, system call tag tracking application **106** determines the application tag associated with the calling process. At **308**, system call tag tracking application **106** determines the application tag associated with the called process. At **310**, the system call security enforcement application **108** determines if the calling process is prohibited from accessing the called process based on the application tags associated with the calling process and the called process (and the security policy, e.g., what kind of mixing is allowed, if at all). The application tags of the calling process and the called process are considered to match if the application tags of the calling process and the called process do not conflict. For example, the application tags of the calling process and the called process may be identical, thereby permitting access. Alternatively, one of the application tags of the calling process and the called process may be neutral, thereby allowing access. Both such cases are considered a match.

If at **310**, the application tags of the calling process and the called process match, flow proceeds to **312** where the access is permitted. The application tag for the current instance of the calling process may be updated to reflect access to the called process (also, the tag of the called process may be updated if data flows from the caller to the callee). If at **310**, the application tags of the calling process and the called process do not match, flow proceeds to **314** where the access is prohibited. At **314**, the user may be notified of the prohibited access through user interface **130**.

If at **304**, the call is an intra-process call, flow proceeds to **316**. For intra-process tag propagation, the application runtime environment **110** tracks each instruction and tags all the individual data or memory objects. At **316**, application tag tracking application **112** determines the application tag associated with the process. At **318**, application tag tracking application **112** determines the data tag associated with the data. At **320**, the application security enforcement application **114** determines if the process is prohibited from accessing the data based on the application tag associated with the process and the data tag. The application tag of the process and the data tag are considered to match if the application tag of the process and the data tag do not conflict. For example, the application tag of the process and the data tag may be identical, thereby permitting access. Alternatively, one of the application tag and the data tag may be neutral, thereby allowing access. Both such cases are considered a match. In other embodiments, the resultant of the processing of the data is observed by application security enforcement application **114**. If the data tag of the output of the process does not match the data tag of the data, then execution of the process can be terminated to prevent the resultant of the process from being output. For example, an application cannot access personal data and output a resultant workplace data. This prevents co-mingling of different types of data.

If at **320**, the application tag of the process and the data tag match, flow proceeds to **322** where the access is permitted. The application tag for the current instance of the process may be updated to reflect access to the data. For example, if an email process access a workplace address or workplace document, then that email instance is assigned the workplace data tag. Further, any data output by the process may be assigned the data tag, so that the data tag propagates through the system. If at **320**, the application tag of the process and the data tag do not match, flow proceeds to **314** where the access is prohibited. At **314**, the user may be notified of the prohibited access through user interface **130**.

Examples of operation of the system are provided to illustrate exemplary embodiments. In one example, a user accesses an email process running on mobile device **10**. Initially, the email process may have no application tag. As the user composes an email, the email process makes a system call through operating system level **104** to an address book process to obtain an email address. The email address, for example, is associated with a data tag (e.g., personal) and thus, the system call tag tracking application **106** assigns a similar application tag to the email (e.g., personal). For sake of illustration, assume the user now attempts to attach a business document to the email. The business document is associated with a data tag of a different type (e.g., workplace). The system call security enforcement application **108** prevents the business document from being attached to the email, as the data tag does not match the application tag. The user would be notified of the prohibition.

In another example, a user obtains a picture using camera **18**. Prior to storage, the picture is received at secure tagging function **102**, in a capsule generated by the camera process. Capsule **200** may be associated with different data tags for the picture depending on the location and/or time when the picture was taken, as determined by sensors **22**. If mobile device **10** is within a certain area (e.g., the workplace) or taken during a certain time (e.g., work hours), the capsule containing the picture is associated with a workplace security level. If mobile device **10** is outside the certain area or time (e.g., on vacation) the capsule containing the picture is associated with a personal security level.

In another example, a user downloads a video to mobile device **10**. The video is contained in capsule that provides digital rights management for the video. The capsule is assigned a data tag that prevents the video from leaving mobile device **10**, so that attempting to email, upload, or otherwise transmit the video would be prohibited. This allows the user of mobile device **10** to view the video using any viewer installed on mobile device **10**, rather than a viewer required by the supplier of the video to manage digital rights.

Embodiments described herein provide fine-grained policy based data-protection as a first class primitive in a mobile device operating system so that the user doesn't have to maintain completely different environments for different categories of data stored on the mobile device. This allows individual data and applications to be contained in micro-security perimeters, referred to as capsules. These capsules can be securely installed on a phone, and are subject to a data security policy defined by the capsule owner. The policy may specify what kinds of data mixing is allowed, and can be a function of the current security context. The operating system tracks the flow of data on a per-capsule basis as it is used by applications on the phone, and enforces the security policies associated with the capsules.

As described above, the exemplary embodiments can be in the form of processor-implemented processes and devices for practicing those processes, such as processor **40**. The exemplary embodiments can also be in the form of computer program code containing instructions embodied in tangible media, such as floppy diskettes, CD ROMs, hard drives, or any other computer-readable storage medium, wherein, when the computer program code is loaded into and executed by a computer, the computer becomes a device for practicing the exemplary embodiments. The exemplary embodiments can also be in the form of computer program code, for example, whether stored in a storage medium, loaded into and/or executed by a computer, or transmitted over some transmission medium, loaded into and/or executed by a computer, or transmitted over some transmission medium, such as over electrical wiring or cabling, through fiber optics, or via electromagnetic radiation, wherein, when the computer program code is loaded into an executed by a computer, the computer becomes an device for practicing the exemplary embodiments. When implemented on a general-purpose microprocessor, the computer program code segments configure the microprocessor to create specific logic circuits.

While the invention has been described with reference to exemplary embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiments disclosed for carrying out this invention, but that the invention will include all embodiments falling within the scope of the claims. Moreover, the use of the terms first, second, etc., do not denote any order or importance, but rather the terms first, second, etc., are used to distinguish one element from another. Furthermore, the use of the terms a, an, etc., do not denote a limitation of quantity, but rather denote the presence of at least one of the referenced item.

What is claimed is:

1. A method, comprising:

in response to receipt from a first application of a first request to access content, permitting, by a computing system, the first application to access the content based at least in part on a match between a first tag associated with the content and a second tag associated with the first application; and

in response to receipt from a second application of a second request to access the content, prohibiting, by the computing system, the second application from accessing the content based at least in part on a mismatch between the first tag and a third tag associated with the second application.

2. The method of claim **1**, further comprising:

storing, by the computing system, the first tag in association with the content;

storing, by the computing system, the second tag in association with the first application; and

storing, by the computing system, the third tag in association with the second application.

3. The method of claim **1**, further comprising:

in response to receipt from the second application of a third request to access other content, permitting, by the computing system, the second application to access the other content based at least in part on a match between a fourth tag associated with the other content and the third tag.

4. The method of claim **3**, further comprising:

in response to receipt from the first application of a fourth request to access the other content, prohibiting, by the computing system, the first application from accessing the other content based at least in part on a mismatch between the fourth tag and the second tag.

5. The method of claim **1**, further comprising:

in response to receipt from the first application of a third request to access other content, prohibiting, by the computing system, the first application from accessing the other content based at least in part on a mismatch between a fourth tag associated with the other content and the second tag.

6. The method of claim **1**, wherein the content includes at least one image.

7. The method of claim **1**, wherein the content includes video.

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

determining, by a third application running at an operating system level of the computing system, that the first tag matches the second tag; and

determining, by the third application, that the first tag does not match the third tag.

9. The method of claim **1**, further comprising:

determining, by a third application running at an application runtime level of the computing system, that the first tag matches the second tag; and

determining, by the third application, that the first tag does not match the third tag.

10. A system, comprising:

one or more processors; and

one or more computer-readable mediums encoded with instructions which, when executed by the one or more processors, cause the system to:

in response to receipt from a first application of a first request to access content, permit the first application to access the content based at least in part on a match between a first tag associated with the content and a second tag associated with the first application; and

in response to receipt from a second application of a second request to access the content, prohibit the second application from accessing the content based at least in part on a mismatch between the first tag and a third tag associated with the second application.

11. The system of claim **10**, wherein the one or more computer-readable mediums are further encoded with additional instructions which, when executed by the one or more processors, further cause the system to:

store the first tag in association with the content;

store the second tag in association with the first application; and

store the third tag in association with the second application.

12. The system of claim **10**, wherein the one or more computer-readable mediums are further encoded with additional instructions which, when executed by the one or more processors, further cause the system to:

in response to receipt from the second application of a third request to access other content, permit the second application to access the other content based at least in part on a match between a fourth tag associated with the other content and the third tag.

13. The system of claim **12**, wherein the one or more computer-readable mediums are further encoded with additional instructions which, when executed by the one or more processors, further cause the system to:

in response to receipt from the first application of a fourth request to access the other content, prohibit the first application from accessing the other content based at least in part on a mismatch between the fourth tag and the second tag.

14. The system of claim **10**, wherein the one or more computer-readable mediums are further encoded with additional instructions which, when executed by the one or more processors, further cause the system to:

in response to receipt from the first application of a third request to access other content, prohibit the first application from accessing the other content based at least in part on a mismatch between a fourth tag associated with the other content and the second tag.

15. The system of claim **10**, wherein the content includes at least one image.

16. The system of claim **10**, wherein the content includes video.

17. The system of claim **10**, wherein the one or more computer-readable mediums are further encoded with additional instructions which, when executed by the one or more processors, further cause the system to:

determine, by a third application running at an operating system level of the system, that the first tag matches the second tag; and

determine, by the third application, that the first tag does not match the third tag.

18. The system of claim **10**, wherein the one or more computer-readable mediums are further encoded with additional instructions which, when executed by the one or more processors, further cause the system to:

determine, by a third application running at an application runtime level of the system, that the first tag matches the second tag; and

determine, by the third application, that the first tag does not match the third tag.

19. One or more non-transitory computer-readable mediums encoded with instructions which, when executed by one or more processors of a system, cause the system to:

in response to receipt from a first application of a first request to access content, permit the first application to access the content based at least in part on a match between a first tag associated with the content and a second tag associated with the first application; and

in response to receipt from a second application of a second request to access the content, prohibit the second application from accessing the content based at least in part on a mismatch between the first tag and a third tag associated with the second application.

20. The one or more non-transitory computer-readable mediums of claim **19**, further encoded with additional instructions which, when executed by the one or more processors, further cause the system to:

store the first tag in association with the content;

store the second tag in association with the first application; and

store the third tag in association with the second application.

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