US009311112B2

(12) **United States Patent**
**Shaffer et al.**

(10) **Patent No.: US 9,311,112 B2**
(45) **Date of Patent: *Apr. 12, 2016**

(54) **EVENT RECOGNITION**

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( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **13/077,931**

(22) Filed: **Mar. 31, 2011**

(65) **Prior Publication Data**

US 2011/0179380 A1 Jul. 21, 2011

**Related U.S. Application Data**

(63) Continuation-in-part of application No. 12/566,660, filed on Sep. 24, 2009, now Pat. No. 8,285,499, which is a continuation-in-part of application No. 12/789,695, filed on May 28, 2010.

(Continued)

(51) **Int. Cl.**
***G06F 3/042*** (2006.01)
***G06F 9/44*** (2006.01)

(Continued)

(52) **U.S. Cl.**
CPC ..... ***G06F 9/4443*** (2013.01); ***G06F 3/04883*** (2013.01); ***G06F 9/542*** (2013.01); *G06F 2209/545* (2013.01)

(58) **Field of Classification Search**
CPC .... G06F 3/04883; G06F 9/4443; G06F 9/542
USPC ..... 345/173; 702/57; 715/746, 863
See application file for complete search history.

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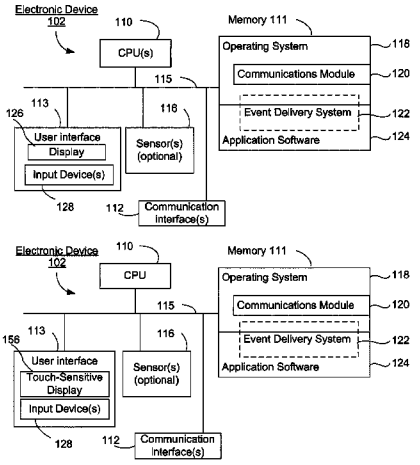
(57) **ABSTRACT**

An electronic device executes one or more software elements. Each software element is associated with a particular view, which includes one or more event recognizers. Each event recognizer has one or more event definitions based on one or more sub-events, and an event handler. The event handler is configured to send an action to a target in response to the event recognizer detecting an event corresponding to a particular event definition. The electronic device detects a sequence of sub-events, and identifies actively involved views. The electronic device delivers a respective sub-event to event recognizers for actively involved views. At least one event recognizer for actively involved views has a plurality of event definitions, one of which is selected in accordance with an internal state of the electronic device. The at least one event recognizer processes the respective sub-event in accordance with the selected event definition.

**30 Claims, 46 Drawing Sheets**






APPLE 1025
Apple v. Smith Interface
IPR2024-01256

**Related U.S. Application Data**

(60) Provisional application No. 61/425,222, filed on Dec. 20, 2010, provisional application No. 61/210,332, filed on Mar. 16, 2009, provisional application No. 61/298,531, filed on Jan. 26, 2010.

(51) **Int. Cl.**
***G06F 3/0488*** (2013.01)
***G06F 9/54*** (2006.01)

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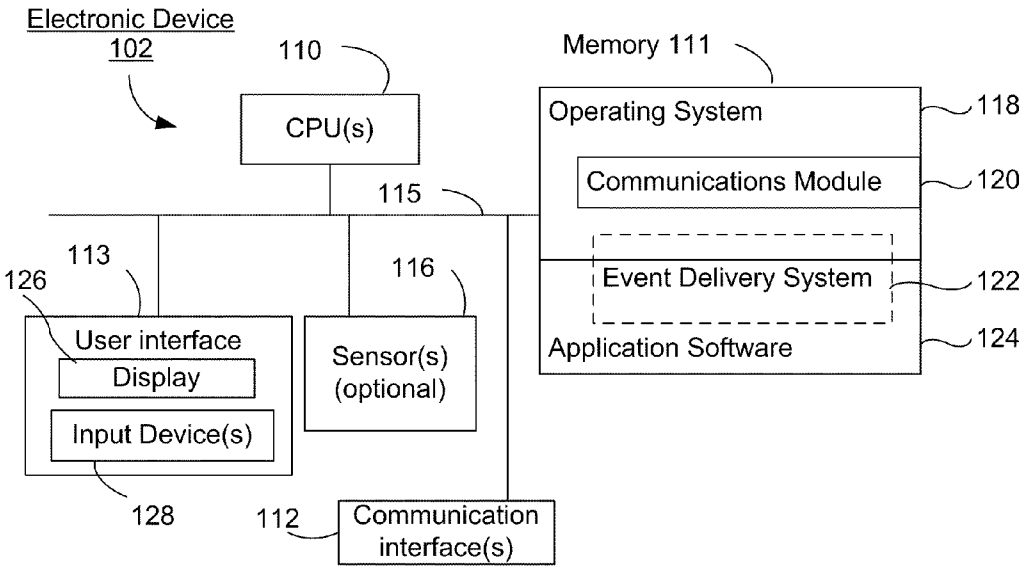



Figure 1A

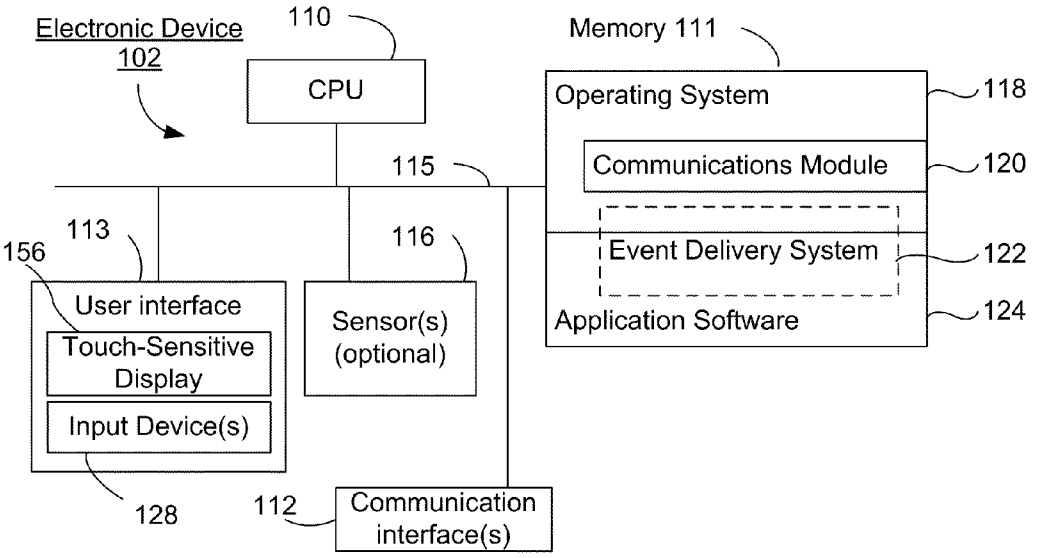
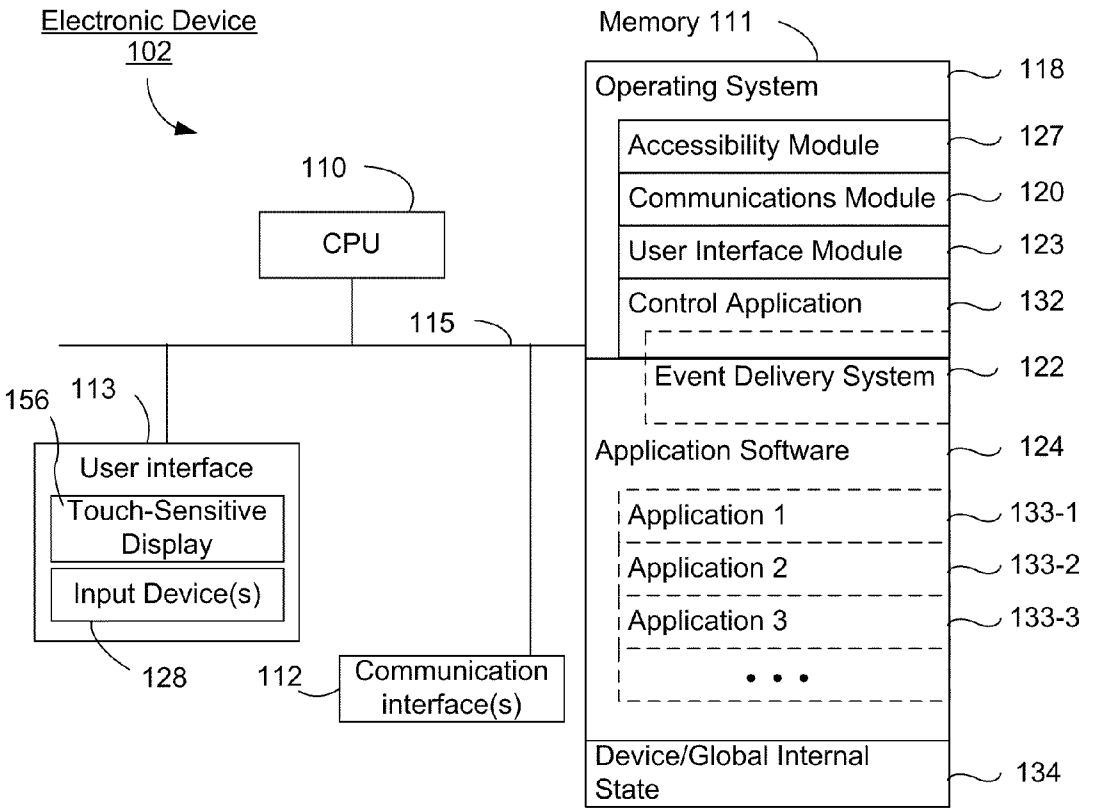



Figure 1B


Electronic Device
102
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CPU
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User interface
Touch-Sensitive Display
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112
Communication interface(s)
Memory 111
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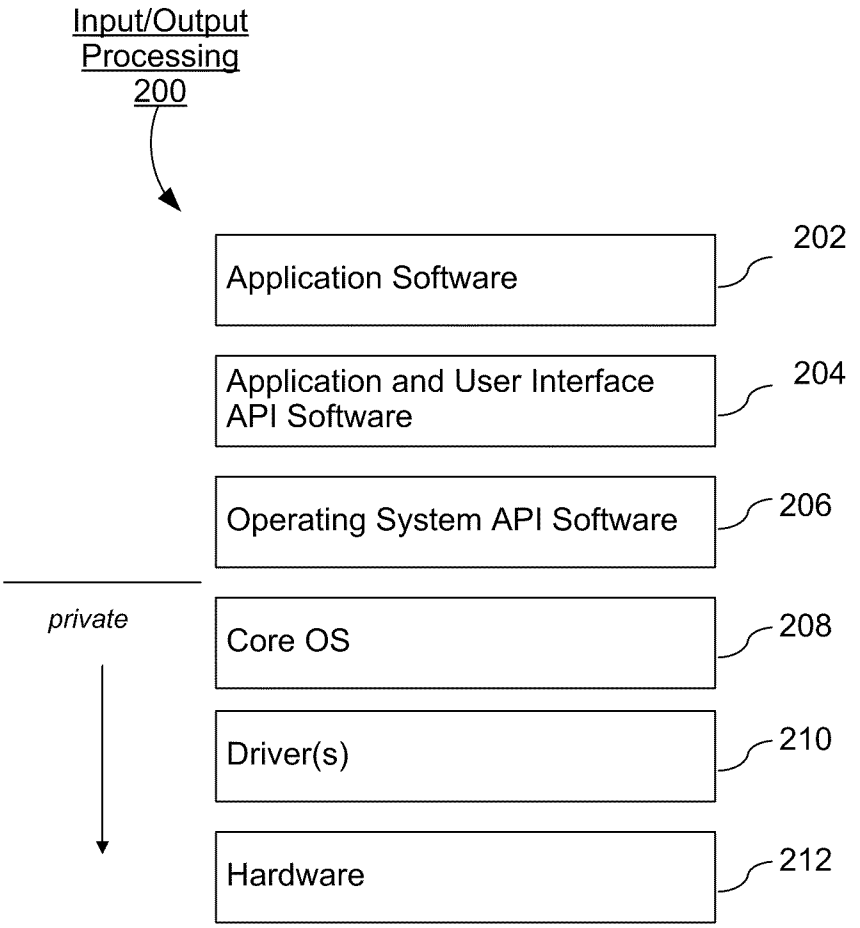
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204
Operating System API Software
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Core OS
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Driver(s)
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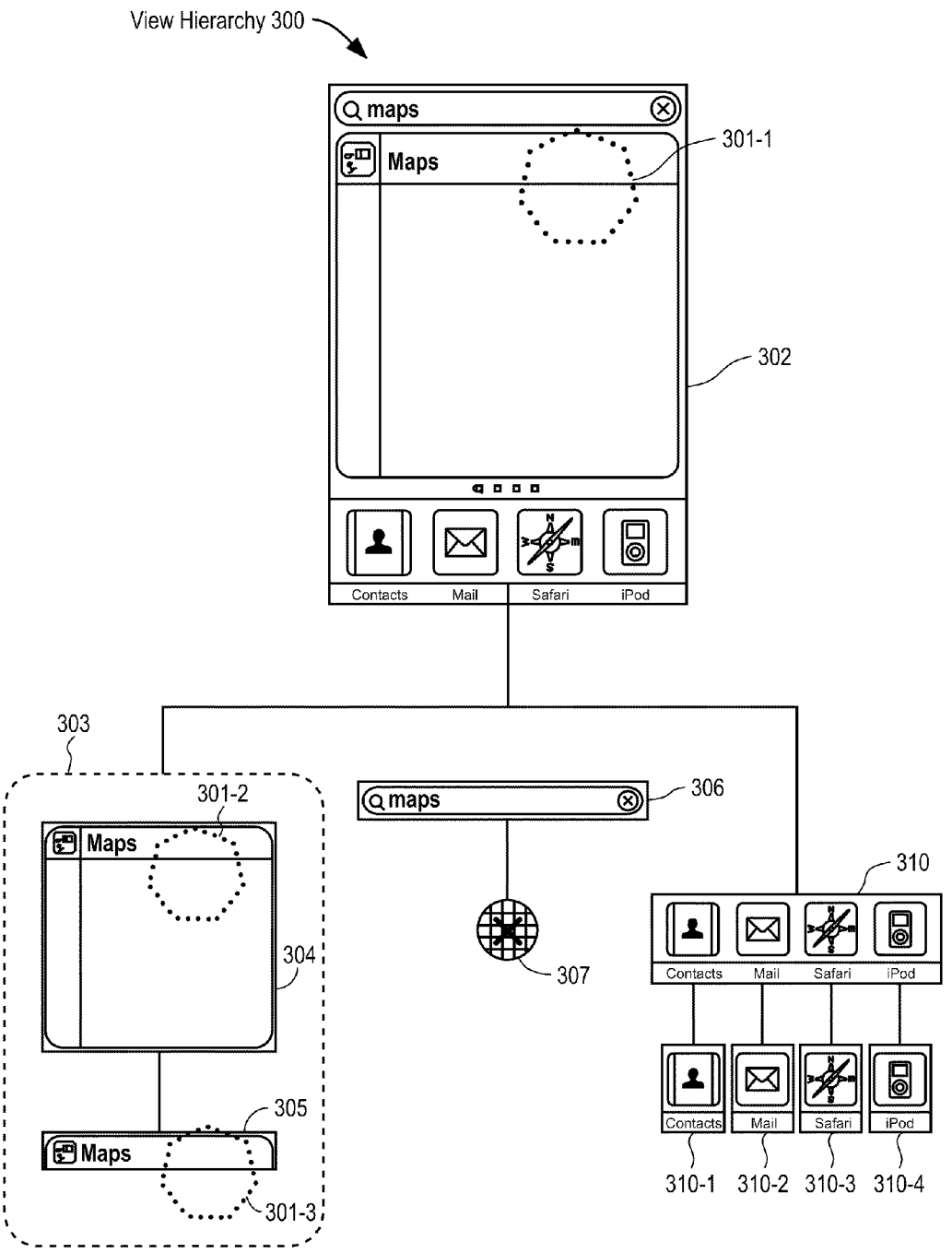
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Contacts
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Safari
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303
301-2
Maps
304
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Maps
301-3
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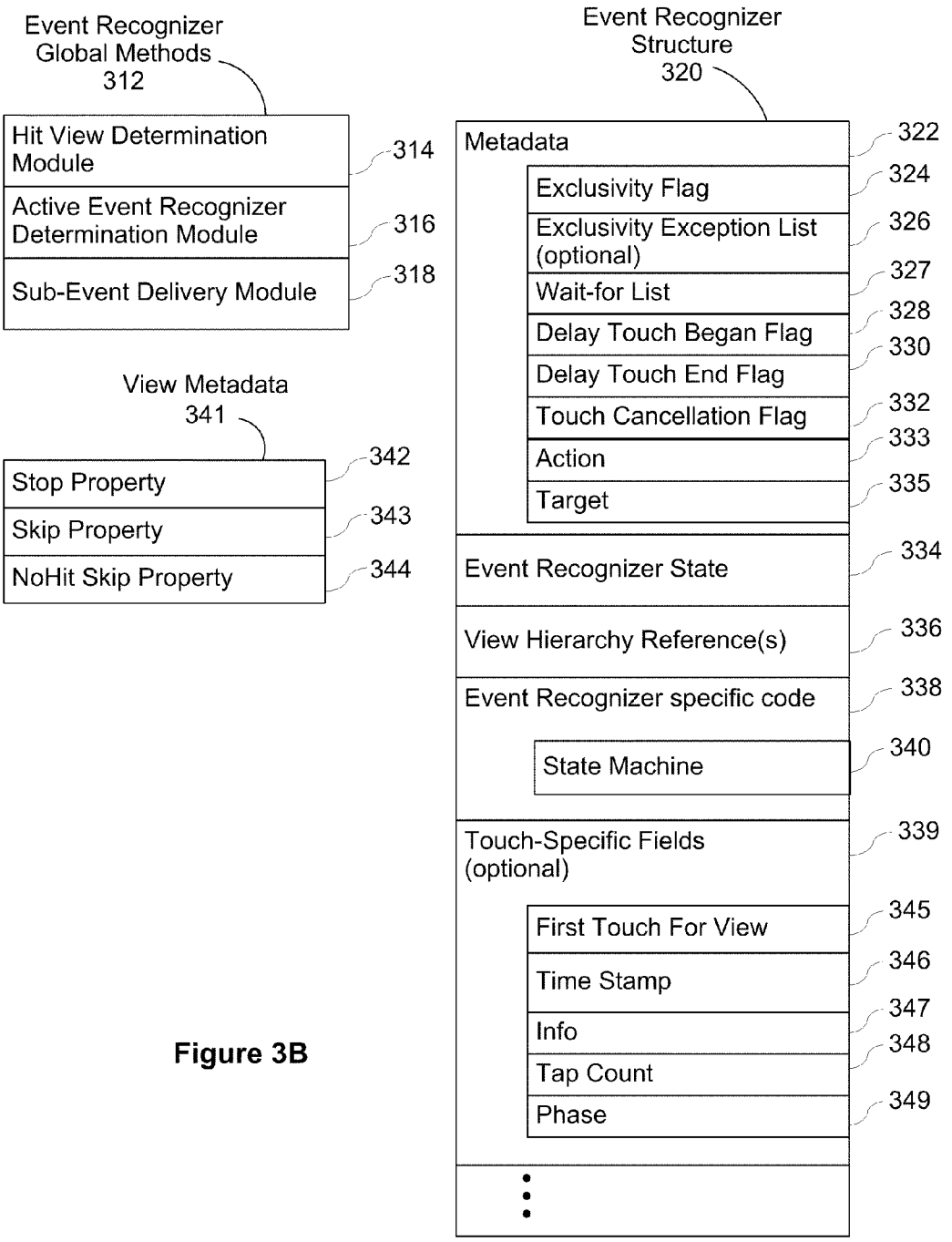
Figure 3A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Active Event Recognizer Determination Module
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318
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Stop Property
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Skip Property
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324
Exclusivity Exception List (optional)
326
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327
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328
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332
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Event Recognizer State
334
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338
State Machine
340
Touch-Specific Fields (optional)
339
First Touch For View
345
Time Stamp
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Tap Count
348
Phase
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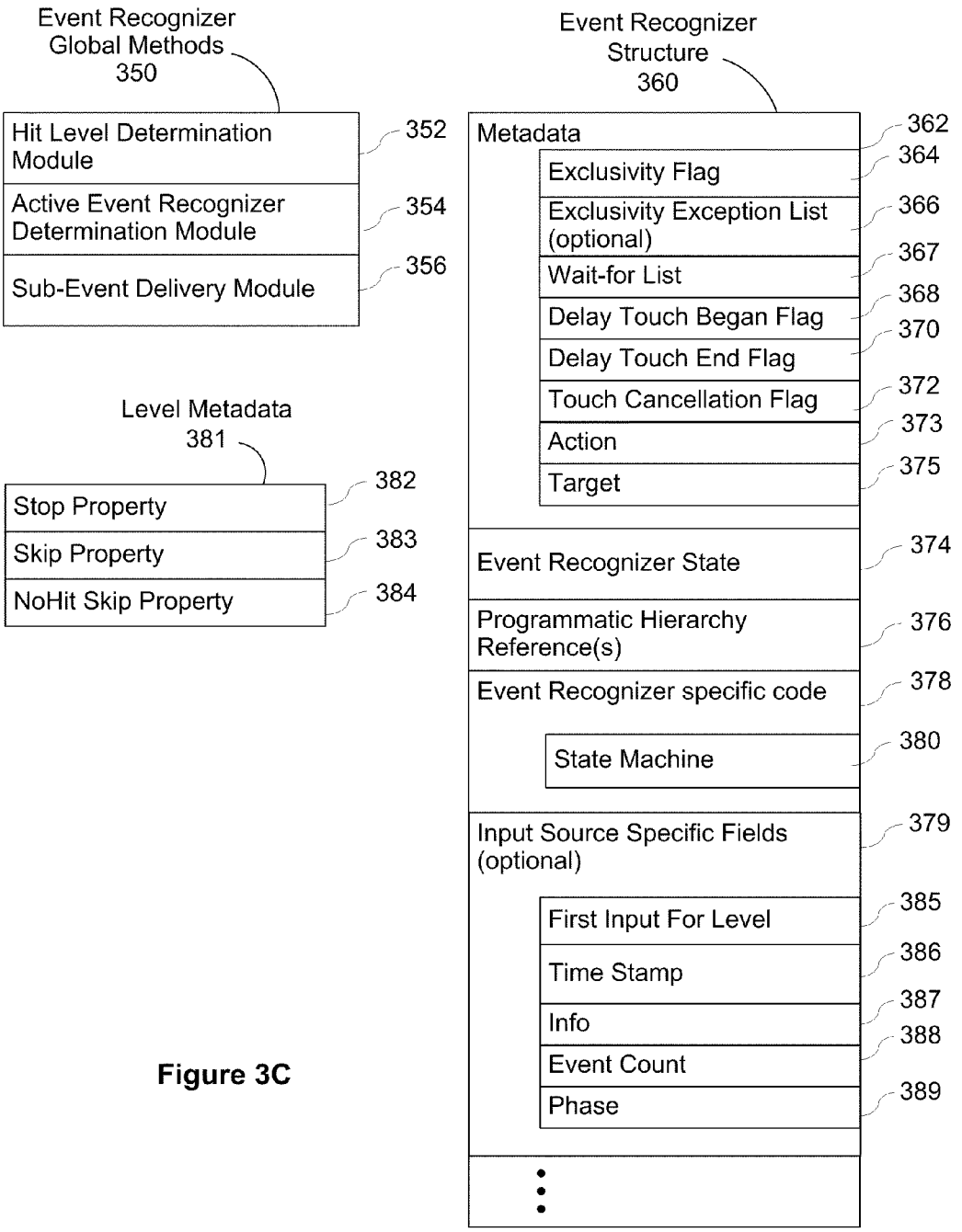
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Sub-Event Delivery Module
356
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362
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364
Exclusivity Exception List (optional)
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Wait-for List
367
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368
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380
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379
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385
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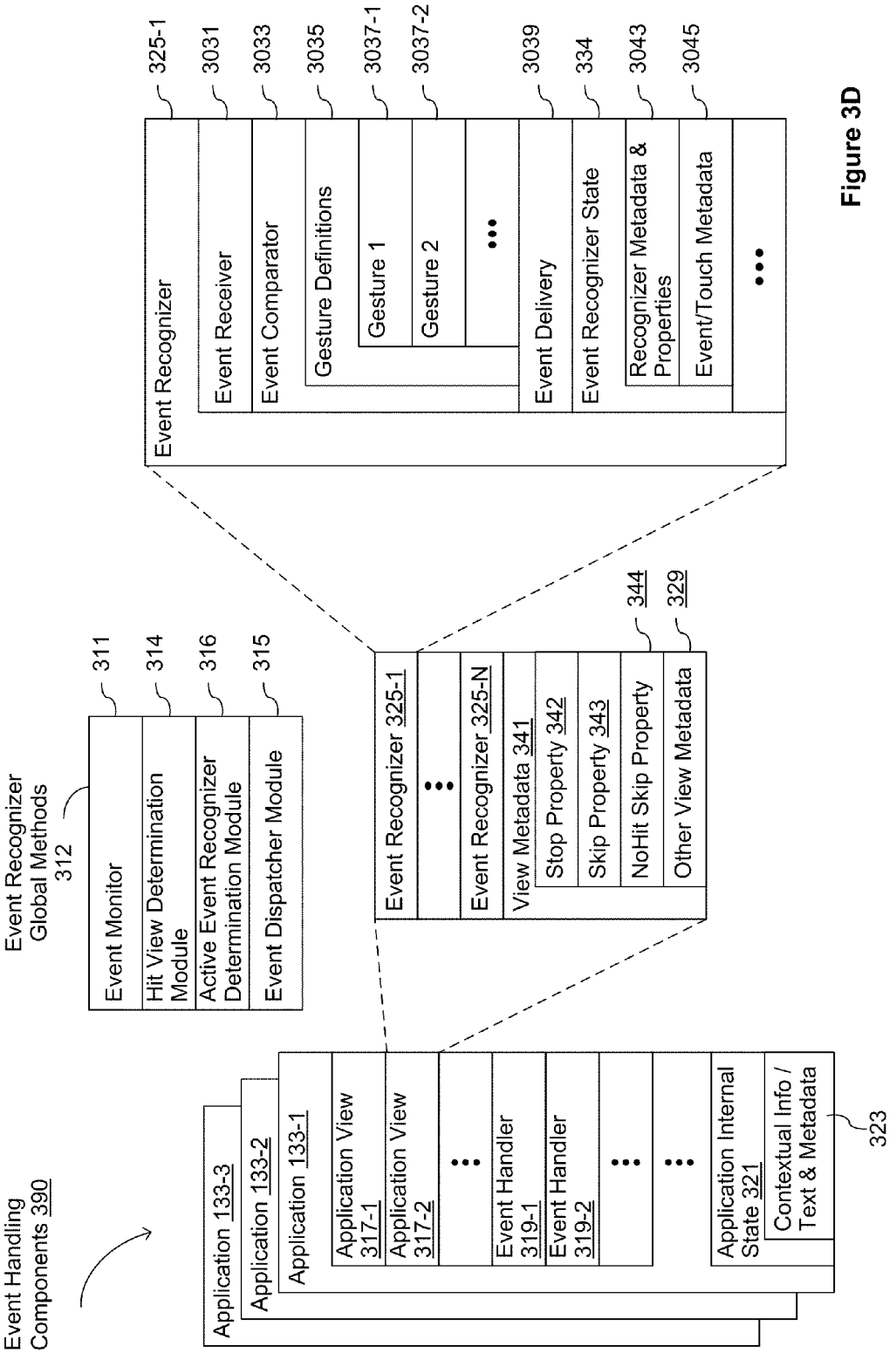
Figure 3C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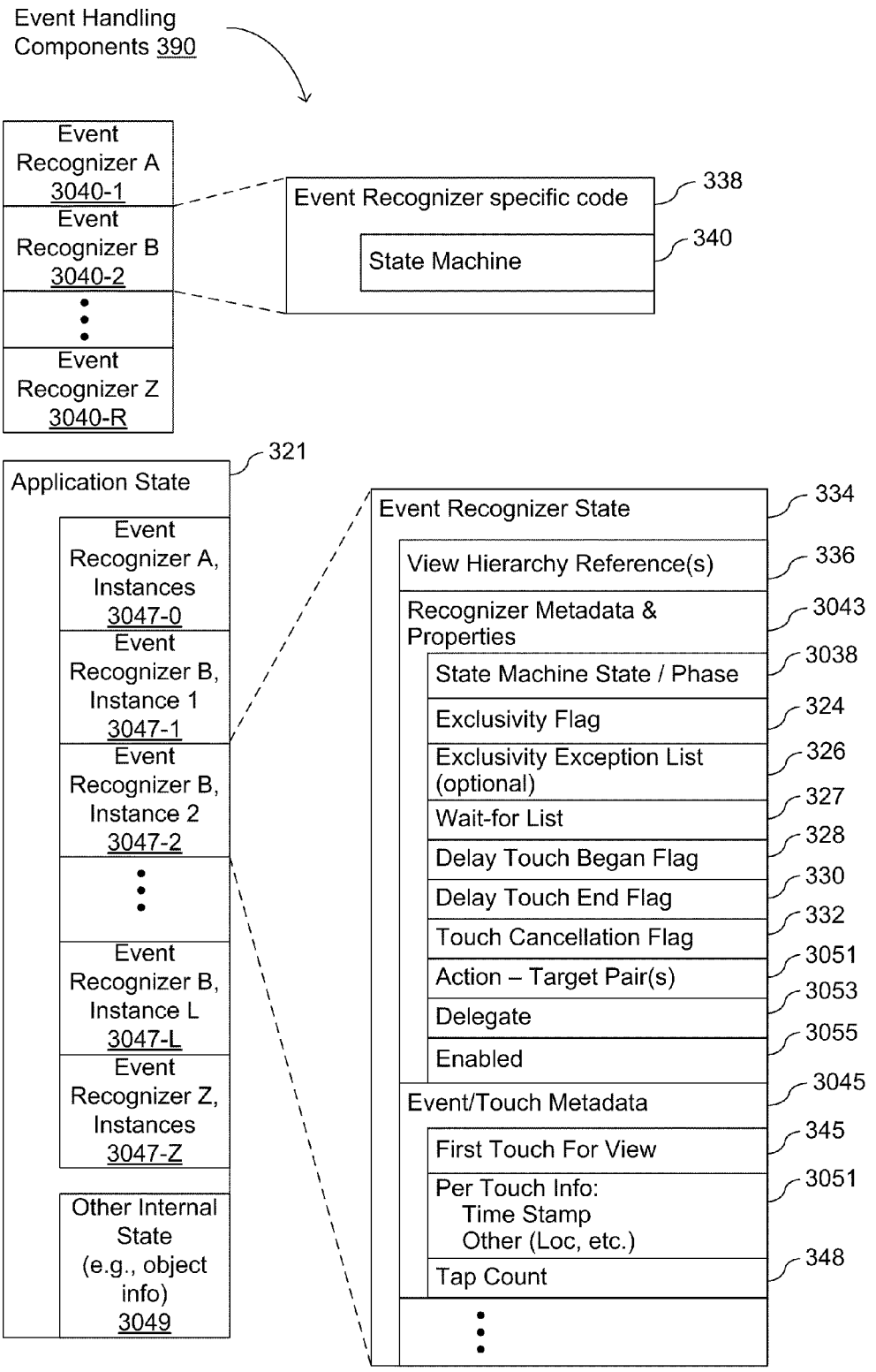
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340
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326
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327
Delay Touch Began Flag
328
Delay Touch End Flag
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Touch Cancellation Flag
332
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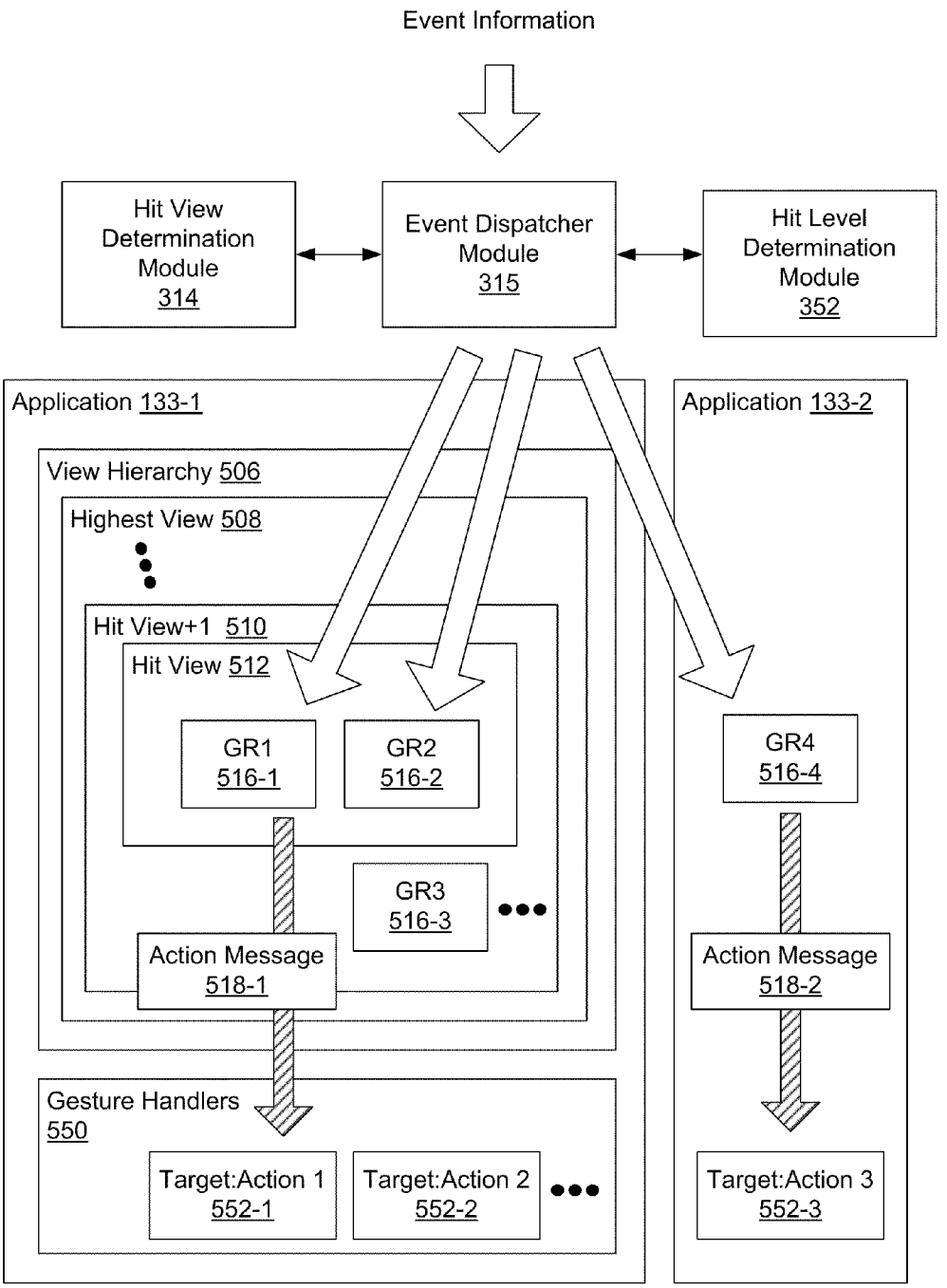
3051
Delegate
3053
Enabled
3055
Event/Touch Metadata
3045
First Touch For View
345
Per Touch Info: Time Stamp Other (Loc, etc.)
3051
Tap Count
348

Figure 3E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Target:Action 2 552-2
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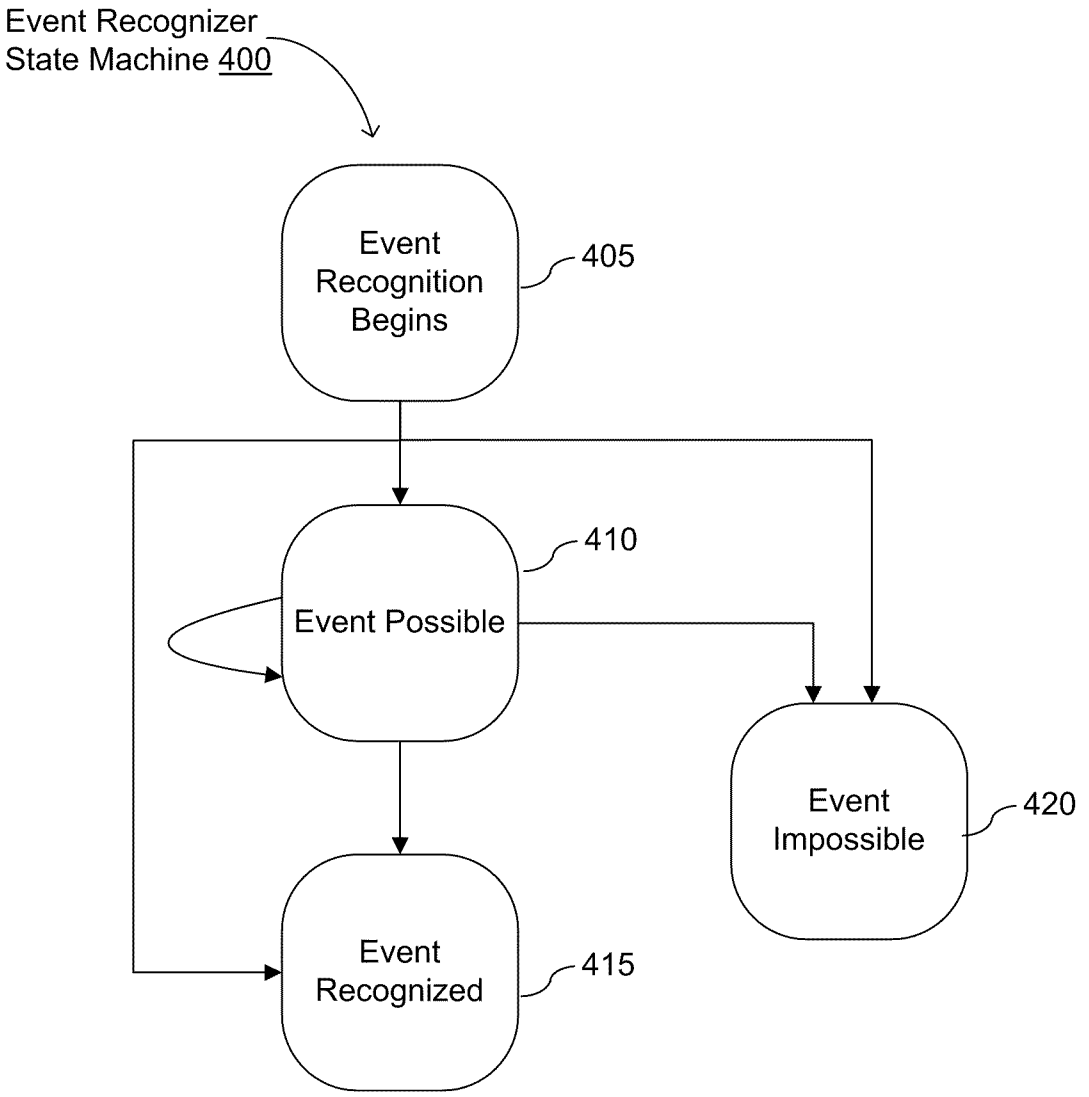
Figure 3F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State Machine 400
Event
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Begins
405
Event Possible
410
Event
Impossible
420
Event
Recognized
415

Figure 4A

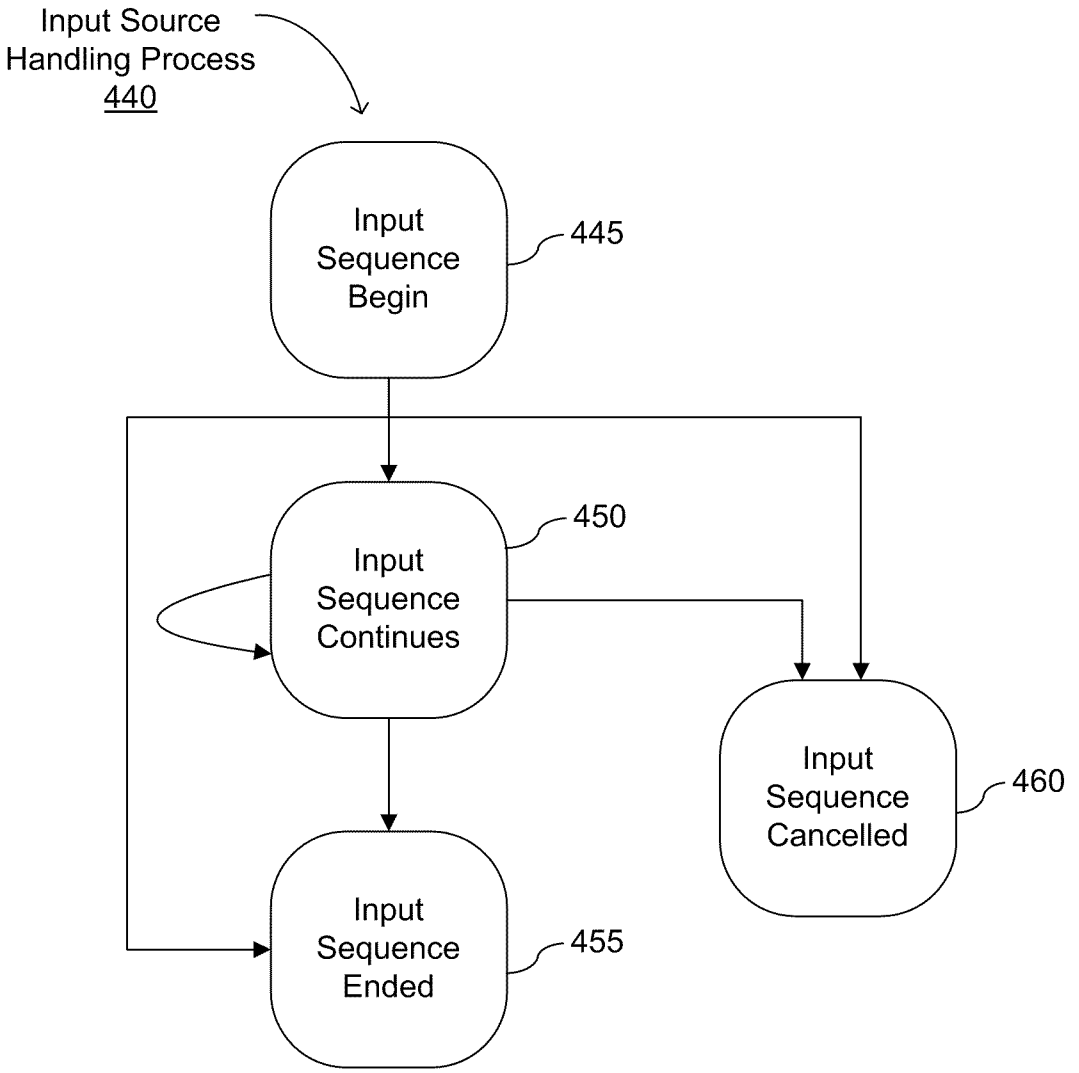

Input Source
Handling Process
440
Input
Sequence
Begin
445
Input
Sequence
Continues
450
Input
Sequence
Cancelled
460
Input
Sequence
Ended
455

Figure 4B

Sub-Event Sequence 465

- Detect finger down 465-1
- Measure delay 465-2
- Detect finger vertical swipe of at least N pixels 465-3
- Detect finger lift off 465-4

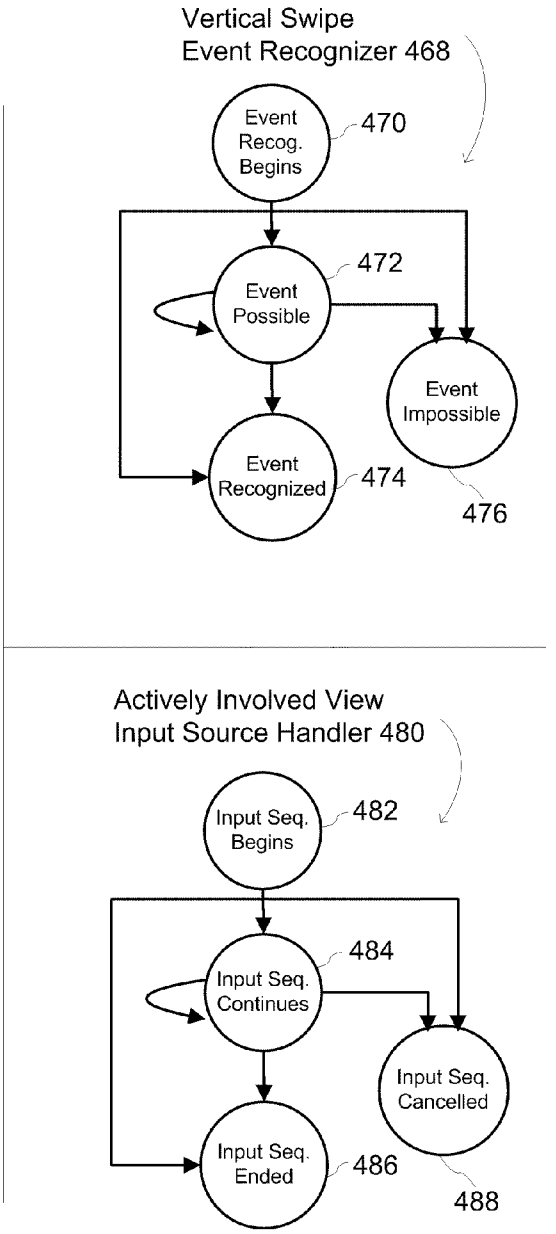



Figure 4C

Sub-Event Sequence 520

- Detect finger down 521-1
- Measure delay 521-2
- Detect finger liftoff 521-3

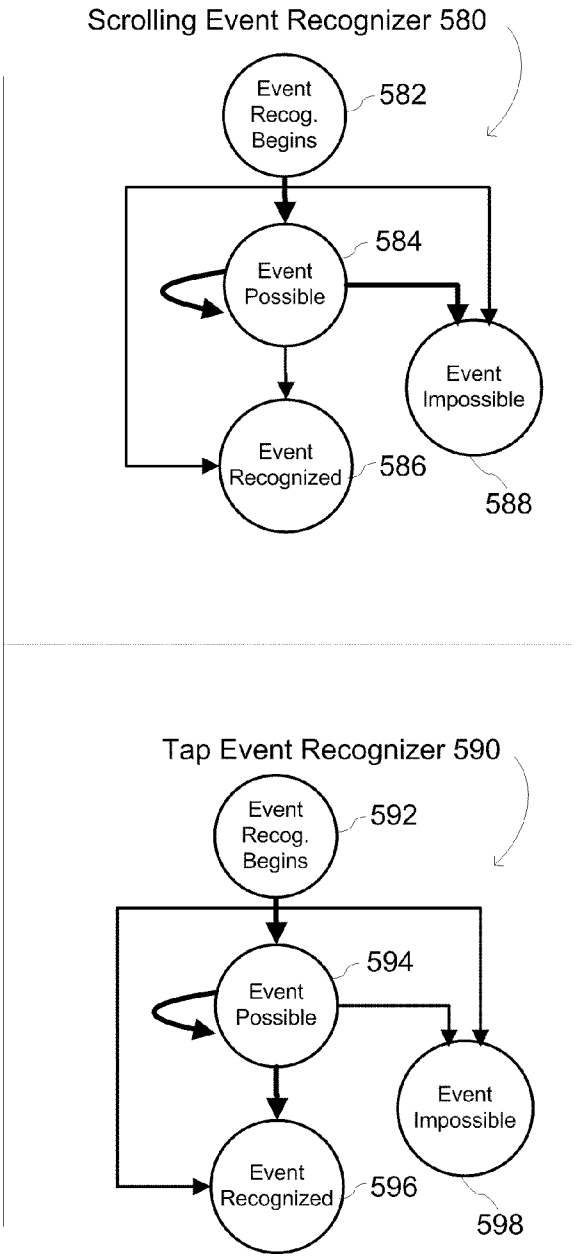



Figure 5A

Sub-Event Sequence 530

- Detect finger down 531-1
- Measure delay 531-2
- Detect finger movement 531-3
- Detect finger lift off 531-4

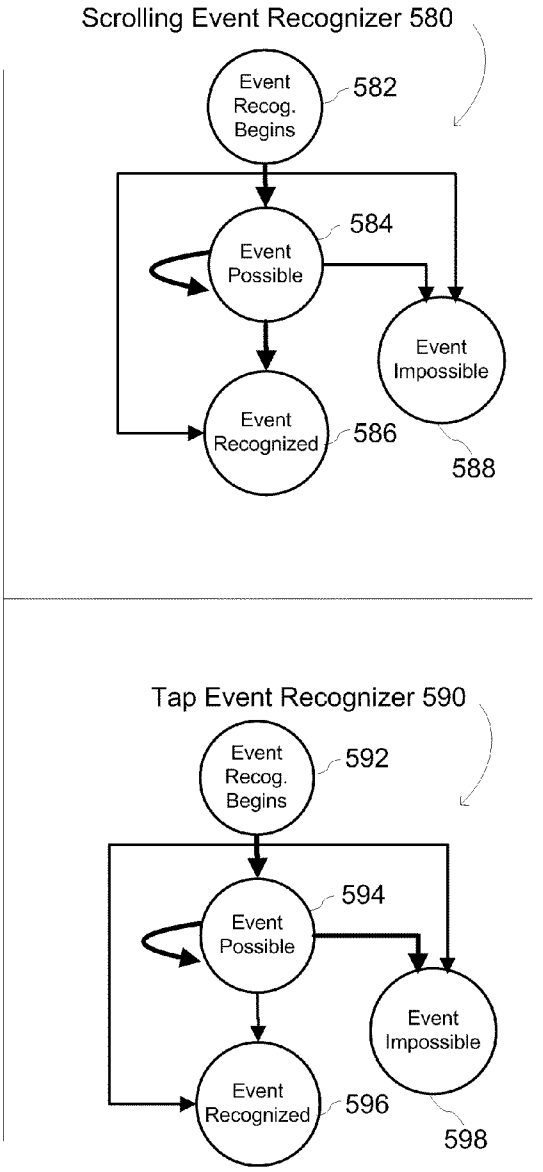
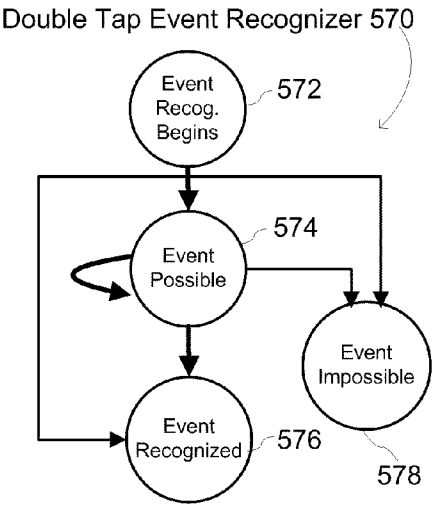



Figure 5B

Sub-Event Sequence 540

- Detect finger down 541-1
- Measure delay 541-2
- Detect finger liftoff 541-3
- Measure delay 541-4
- Detect finger down 541-5
- Measure delay 541-6
- Detect finger liftoff 541-7



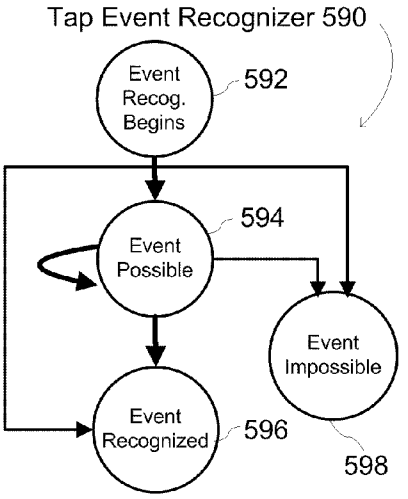




Figure 5C

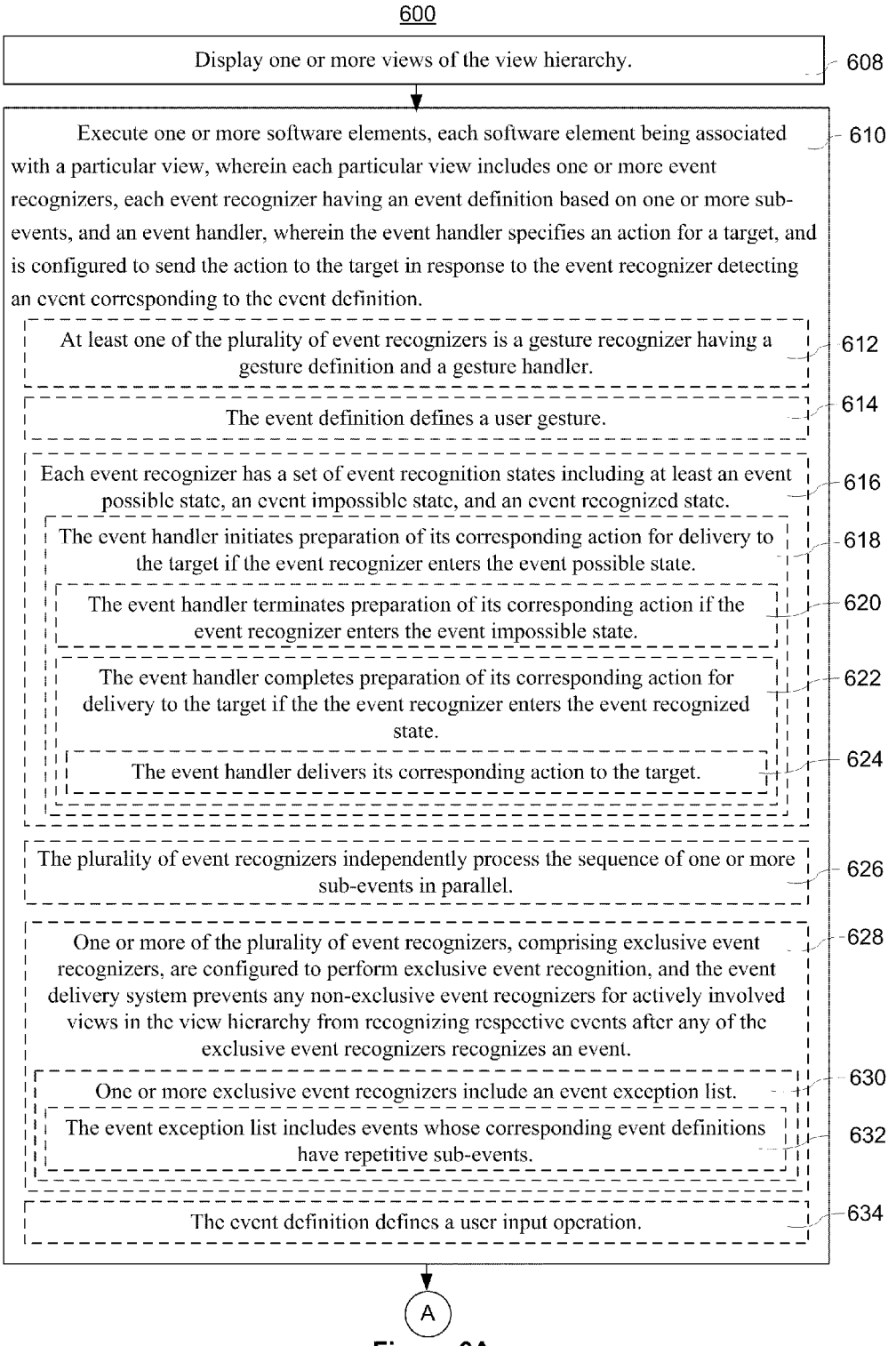

600
Display one or more views of the view hierarchy.
608
Execute one or more software elements, each software element being associated with a particular view, wherein each particular view includes one or more event recognizers, each event recognizer having an event definition based on one or more sub-events, and an event handler, wherein the event handler specifies an action for a target, and is configured to send the action to the target in response to the event recognizer detecting an event corresponding to the event definition.
610
At least one of the plurality of event recognizers is a gesture recognizer having a gesture definition and a gesture handler.
612
The event definition defines a user gesture.
614
Each event recognizer has a set of event recognition states including at least an event possible state, an event impossible state, and an event recognized state.
616
The event handler initiates preparation of its corresponding action for delivery to the target if the event recognizer enters the event possible state.
618
The event handler terminates preparation of its corresponding action if the event recognizer enters the event impossible state.
620
The event handler completes preparation of its corresponding action for delivery to the target if the the event recognizer enters the event recognized state.
622
The event handler delivers its corresponding action to the target.
624
The plurality of event recognizers independently process the sequence of one or more sub-events in parallel.
626
One or more of the plurality of event recognizers, comprising exclusive event recognizers, are configured to perform exclusive event recognition, and the event delivery system prevents any non-exclusive event recognizers for actively involved views in the view hierarchy from recognizing respective events after any of the exclusive event recognizers recognizes an event.
628
One or more exclusive event recognizers include an event exception list.
630
The event exception list includes events whose corresponding event definitions have repetitive sub-events.
632
The event definition defines a user input operation.
634
A

Figure 6A

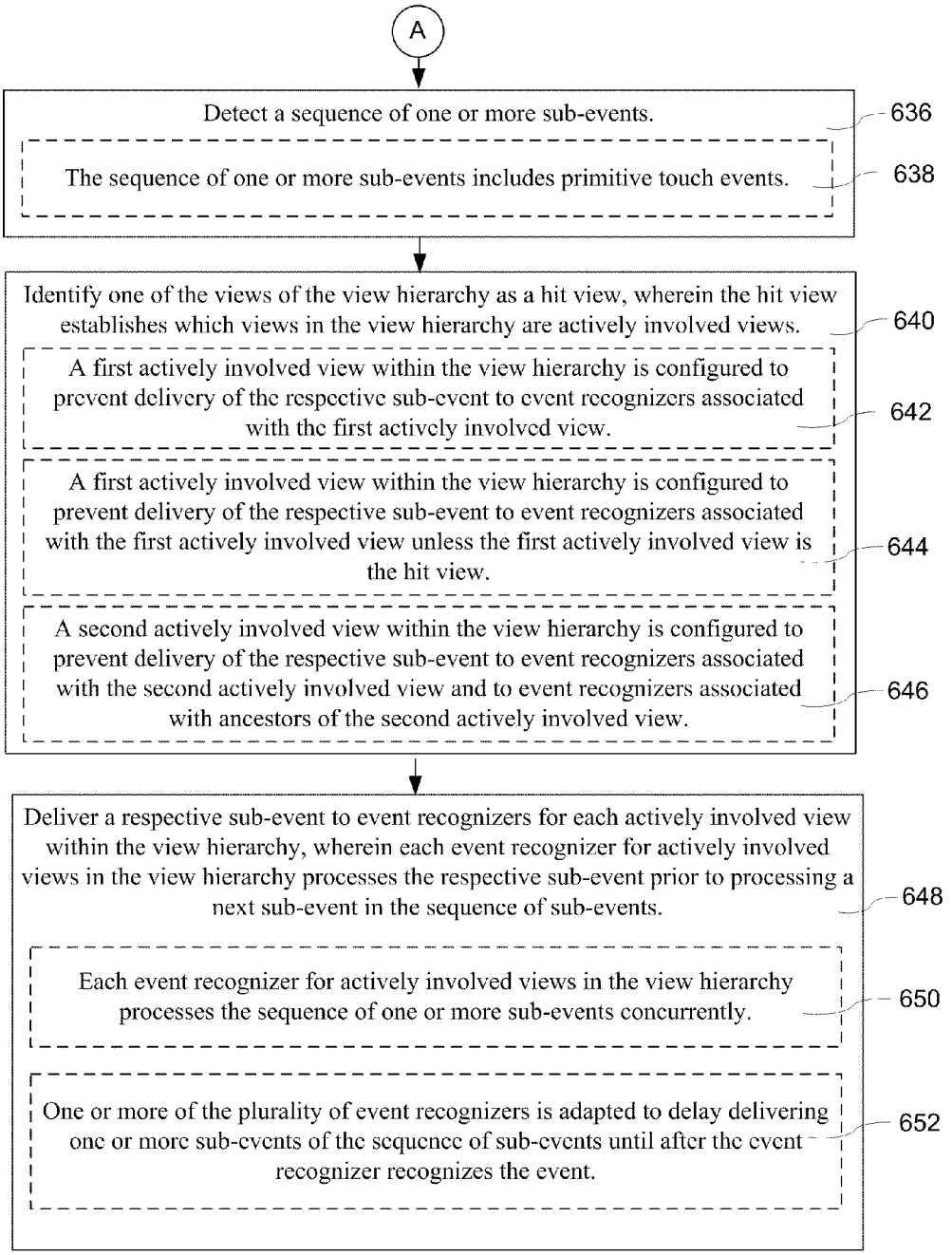

A
Detect a sequence of one or more sub-events.
636
The sequence of one or more sub-events includes primitive touch events.
638
Identify one of the views of the view hierarchy as a hit view, wherein the hit view establishes which views in the view hierarchy are actively involved views.
640
A first actively involved view within the view hierarchy is configured to prevent delivery of the respective sub-event to event recognizers associated with the first actively involved view.
642
A first actively involved view within the view hierarchy is configured to prevent delivery of the respective sub-event to event recognizers associated with the first actively involved view unless the first actively involved view is the hit view.
644
A second actively involved view within the view hierarchy is configured to prevent delivery of the respective sub-event to event recognizers associated with the second actively involved view and to event recognizers associated with ancestors of the second actively involved view.
646
Deliver a respective sub-event to event recognizers for each actively involved view within the view hierarchy, wherein each event recognizer for actively involved views in the view hierarchy processes the respective sub-event prior to processing a next sub-event in the sequence of sub-events.
648
Each event recognizer for actively involved views in the view hierarchy processes the sequence of one or more sub-events concurrently.
650
One or more of the plurality of event recognizers is adapted to delay delivering one or more sub-events of the sequence of sub-events until after the event recognizer recognizes the event.
652

**Figure 6B**

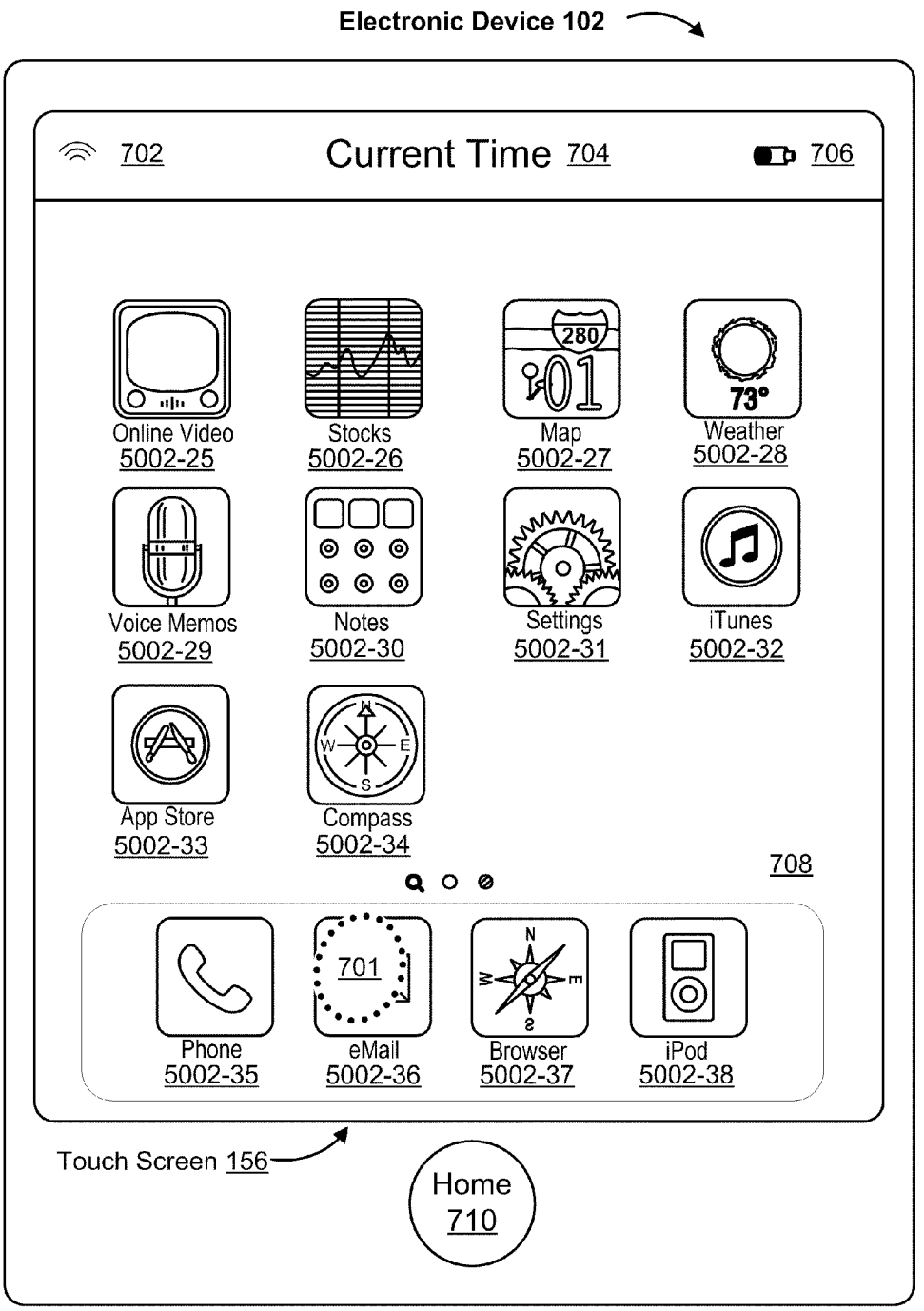

Electronic Device 102
702
Current Time 704
706
Online Video
5002-25
Stocks
5002-26
Map
5002-27
Weather
5002-28
Voice Memos
5002-29
Notes
5002-30
Settings
5002-31
iTunes
5002-32
App Store
5002-33
Compass
5002-34
708
Phone
5002-35
701
eMail
5002-36
Browser
5002-37
iPod
5002-38
Touch Screen 156
Home
710

Figure 7A

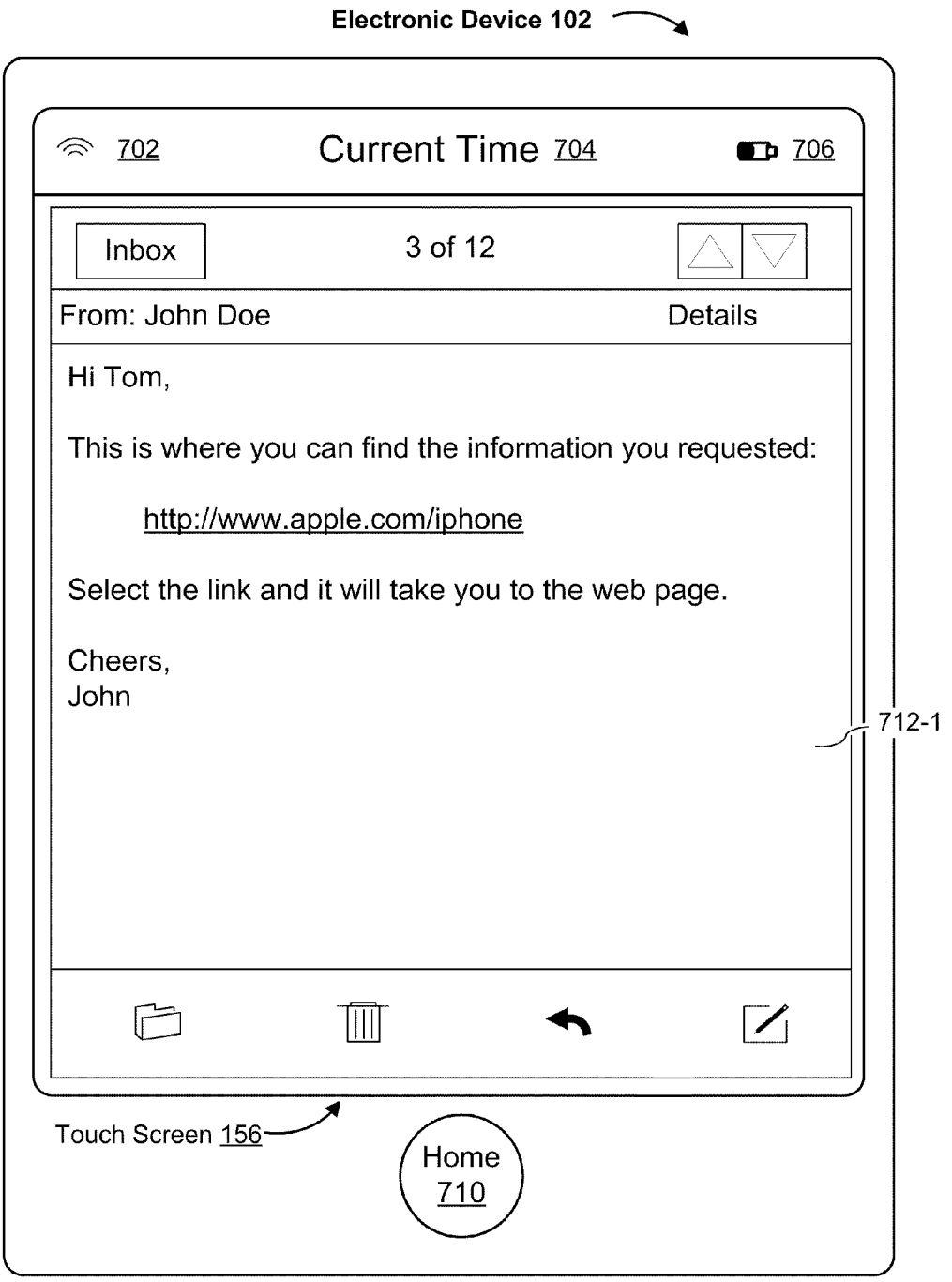

Electronic Device 102
702
Current Time 704
706
Inbox
3 of 12
From: John Doe
Details
Hi Tom,
This is where you can find the information you requested:
http://www.apple.com/iphone
Select the link and it will take you to the web page.
Cheers,
John
712-1
Touch Screen 156
Home
710

Figure 7B

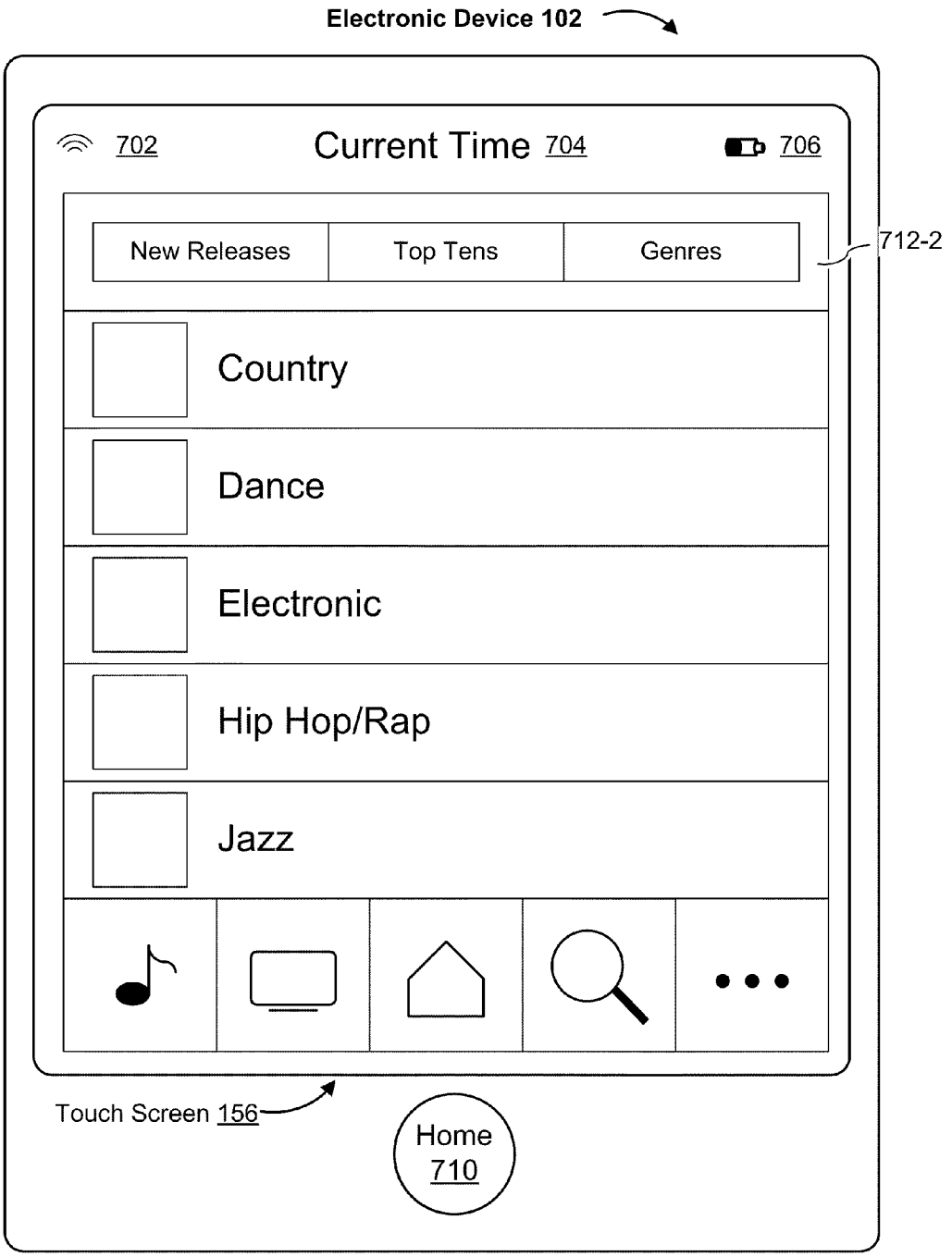

Electronic Device 102
702
Current Time 704
706
New Releases
Top Tens
Genres
712-2
Country
Dance
Electronic
Hip Hop/Rap
Jazz
Touch Screen 156
Home
710

Figure 7C

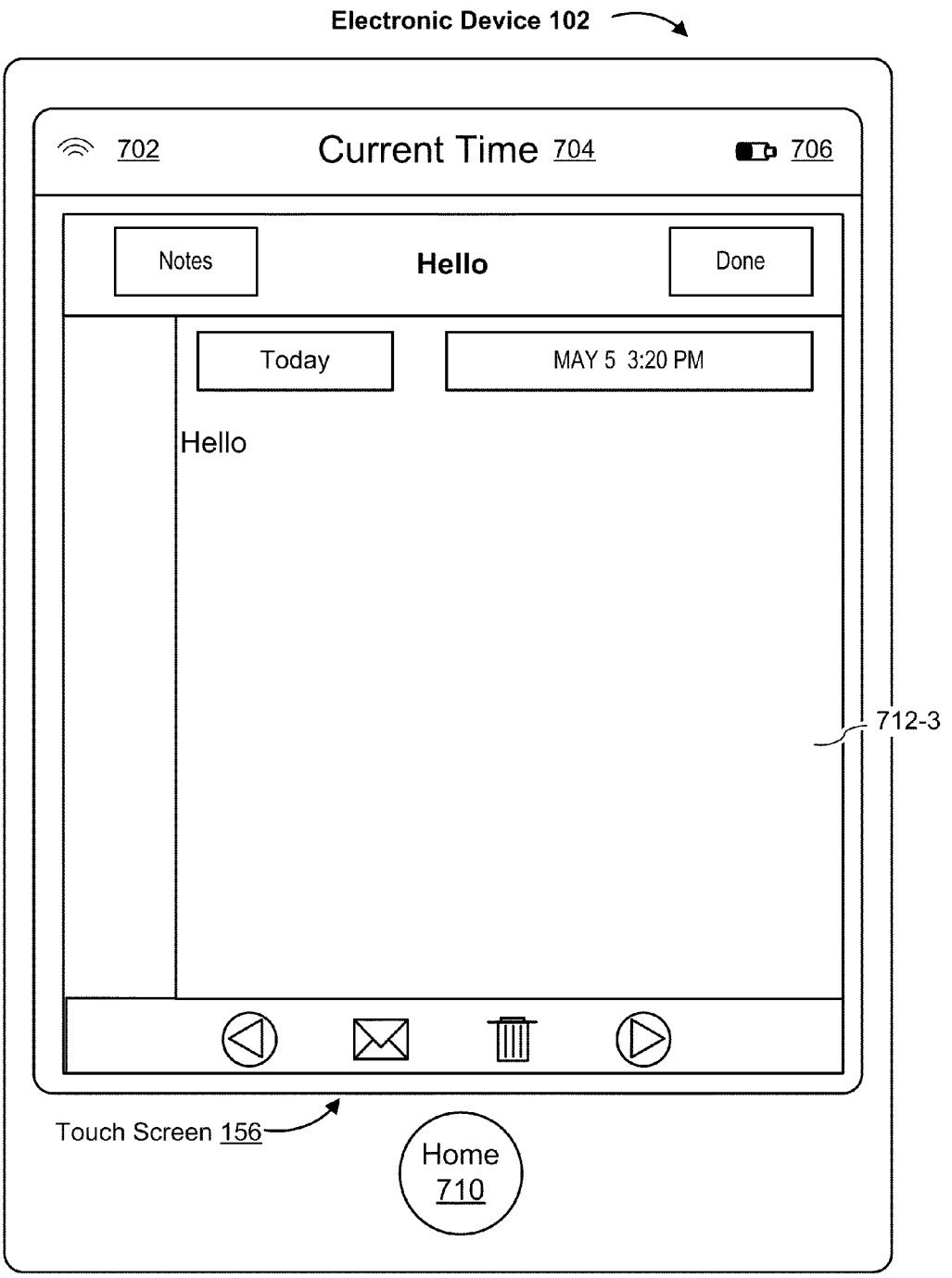

Electronic Device 102
702
Current Time 704
706
Notes
Hello
Done
Today
MAY 5 3:20 PM
Hello
712-3
Touch Screen 156
Home
710

Figure 7D

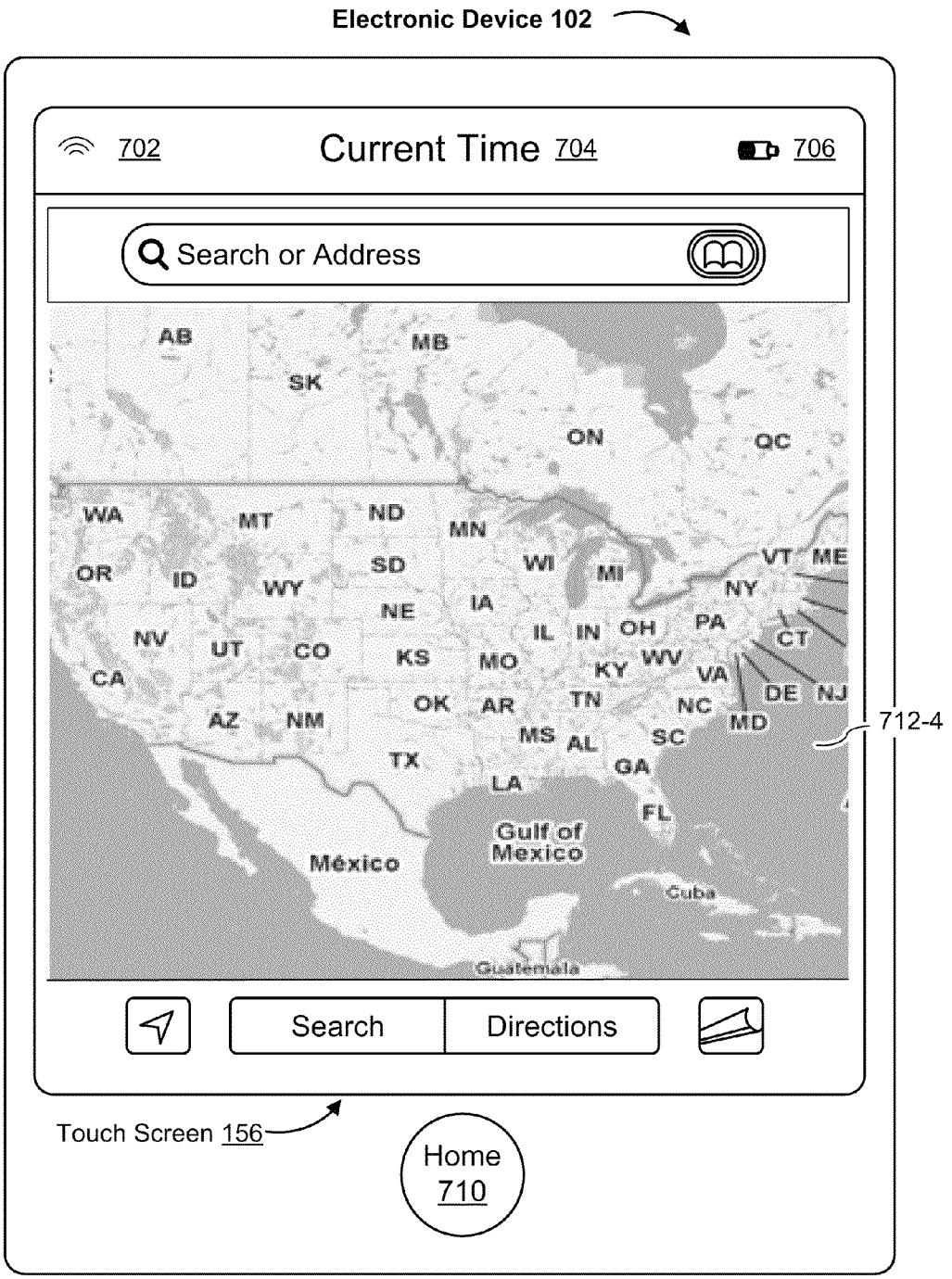

Electronic Device 102
702
Current Time 704
706
Search or Address
AB
MB
SK
ON
QC
WA
MT
ND
MN
OR
ID
WY
SD
WI
MI
VT
ME
NY
NE
IA
PA
CT
NV
UT
CO
KS
MO
IL
IN
OH
WV
KY
VA
CA
DE
NJ
OK
AR
TN
NC
MD
AZ
NM
MS
AL
SC
712-4
TX
GA
LA
FL
Gulf of Mexico
México
Cuba
Guatemala
Search
Directions
Touch Screen 156
Home 710

Figure 7E

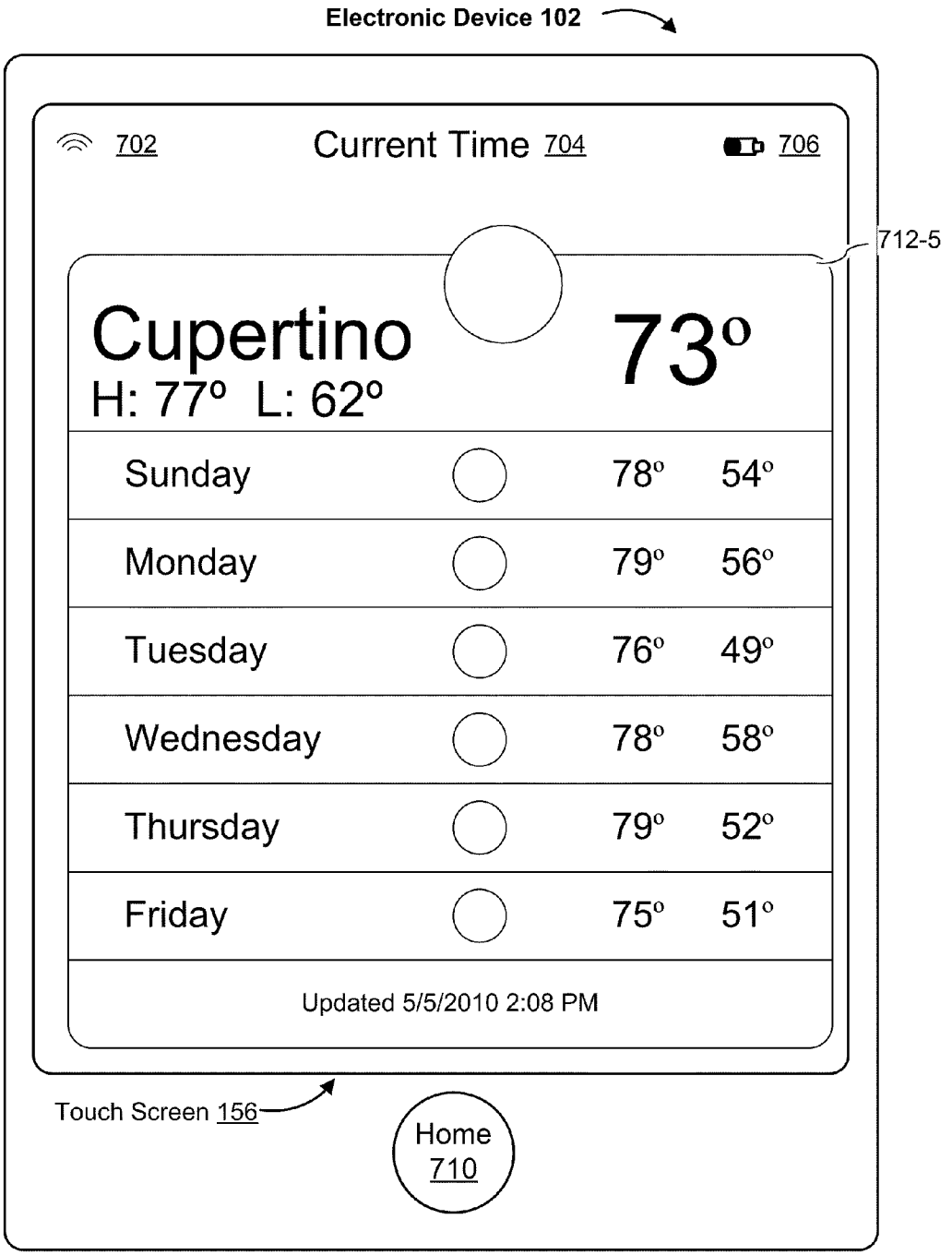
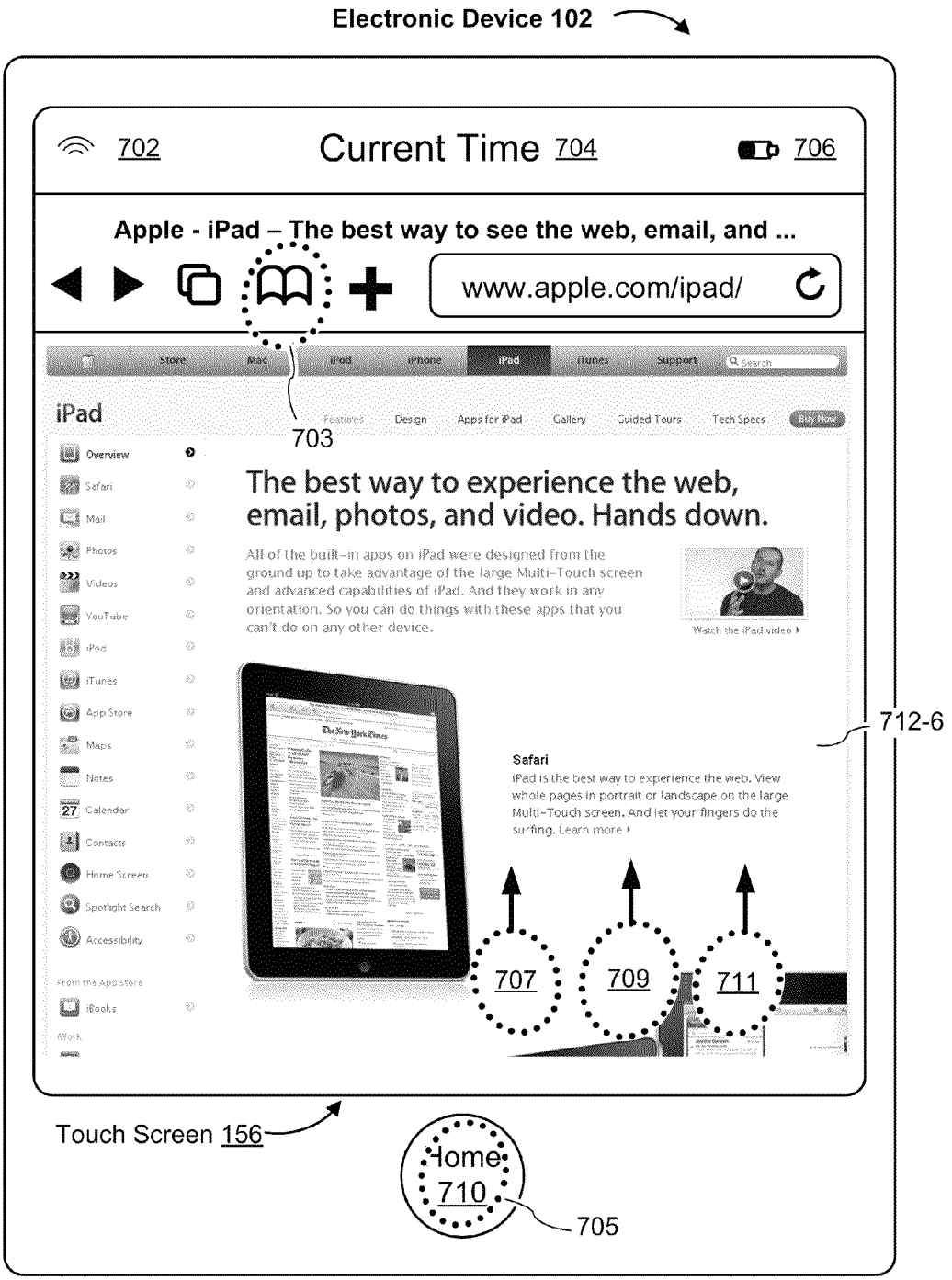

Electronic Device 102
702
Current Time 704
706
712-5
Cupertino
H: 77° L: 62°
73°
Sunday 78° 54°
Monday 79° 56°
Tuesday 76° 49°
Wednesday 78° 58°
Thursday 79° 52°
Friday 75° 51°
Updated 5/5/2010 2:08 PM
Touch Screen 156
Home 710

Figure 7F


Electronic Device 102
702
Current Time 704
706
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Store
Mac
iPod
iPhone
iPad
iTunes
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iPad
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Design
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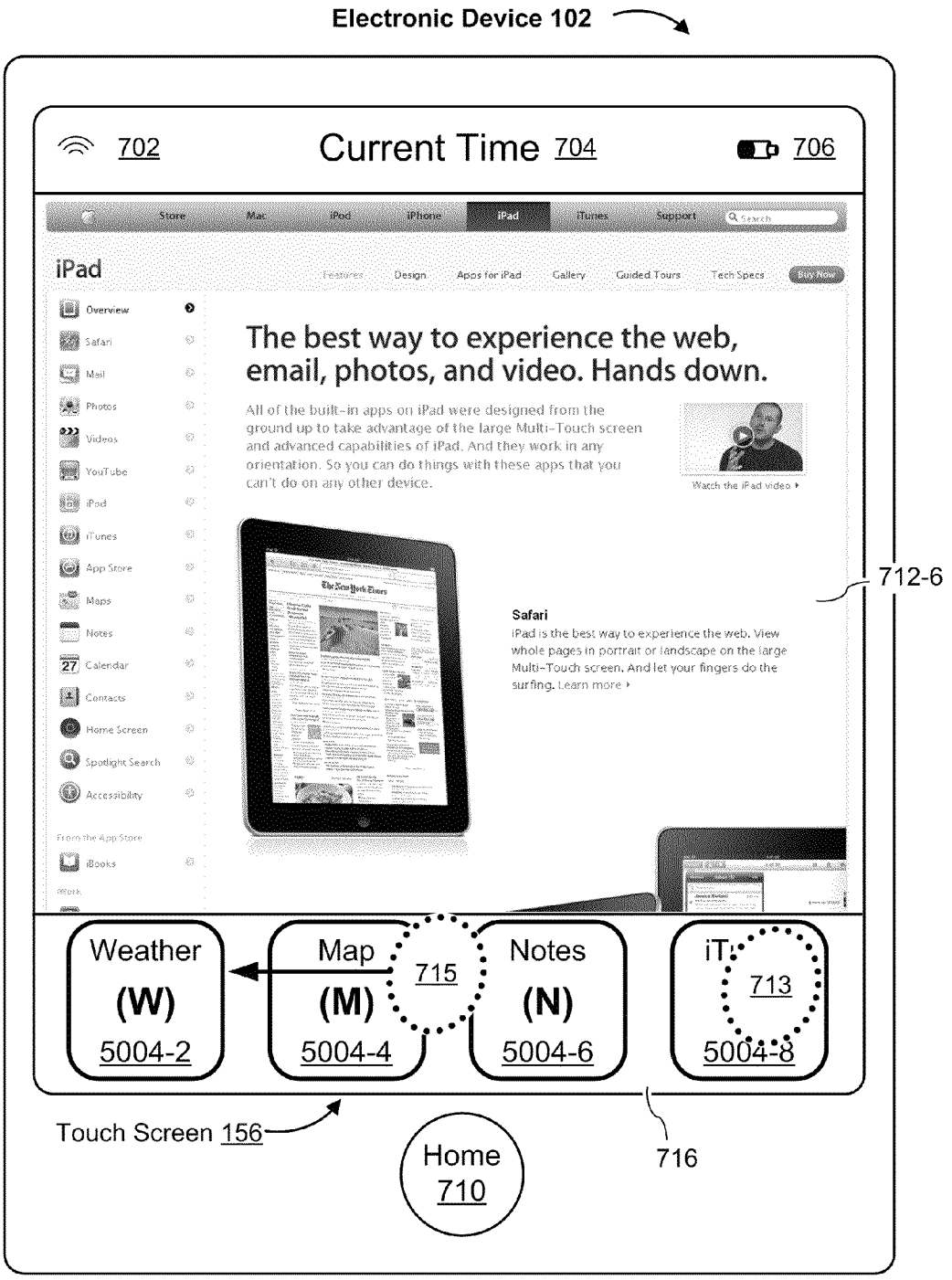
Gallery
Guided Tours
Tech Specs
Buy Now
703
Overview
Safari
Mail
Photos
Videos
YouTube
iPod
iTunes
App Store
Maps
Notes
Calendar
Contacts
Home Screen
Spotlight Search
Accessibility
From the App Store
iBooks
Work
The best way to experience the web, email, photos, and video. Hands down.
All of the built-in apps on iPad were designed from the ground up to take advantage of the large Multi-Touch screen and advanced capabilities of iPad. And they work in any orientation. So you can do things with these apps that you can't do on any other device.
Watch the iPad video
712-6
Safari
iPad is the best way to experience the web. View whole pages in portrait or landscape on the large Multi-Touch screen. And let your fingers do the surfing. Learn more
707
709
711
Touch Screen 156
Home
710
705

Figure 7G


Electronic Device 102
702
Current Time 704
706
Store
Mac
iPod
iPhone
iPad
iTunes
Support
iPad
Features
Design
Apps for iPad
Gallery
Guided Tours
Tech Specs
Buy Now
Overview
Safari
Mail
Photos
Videos
YouTube
iPod
iTunes
App Store
Maps
Notes
Calendar
Contacts
Home Screen
Spotlight Search
Accessibility
From the App Store
iBooks
The best way to experience the web, email, photos, and video. Hands down.
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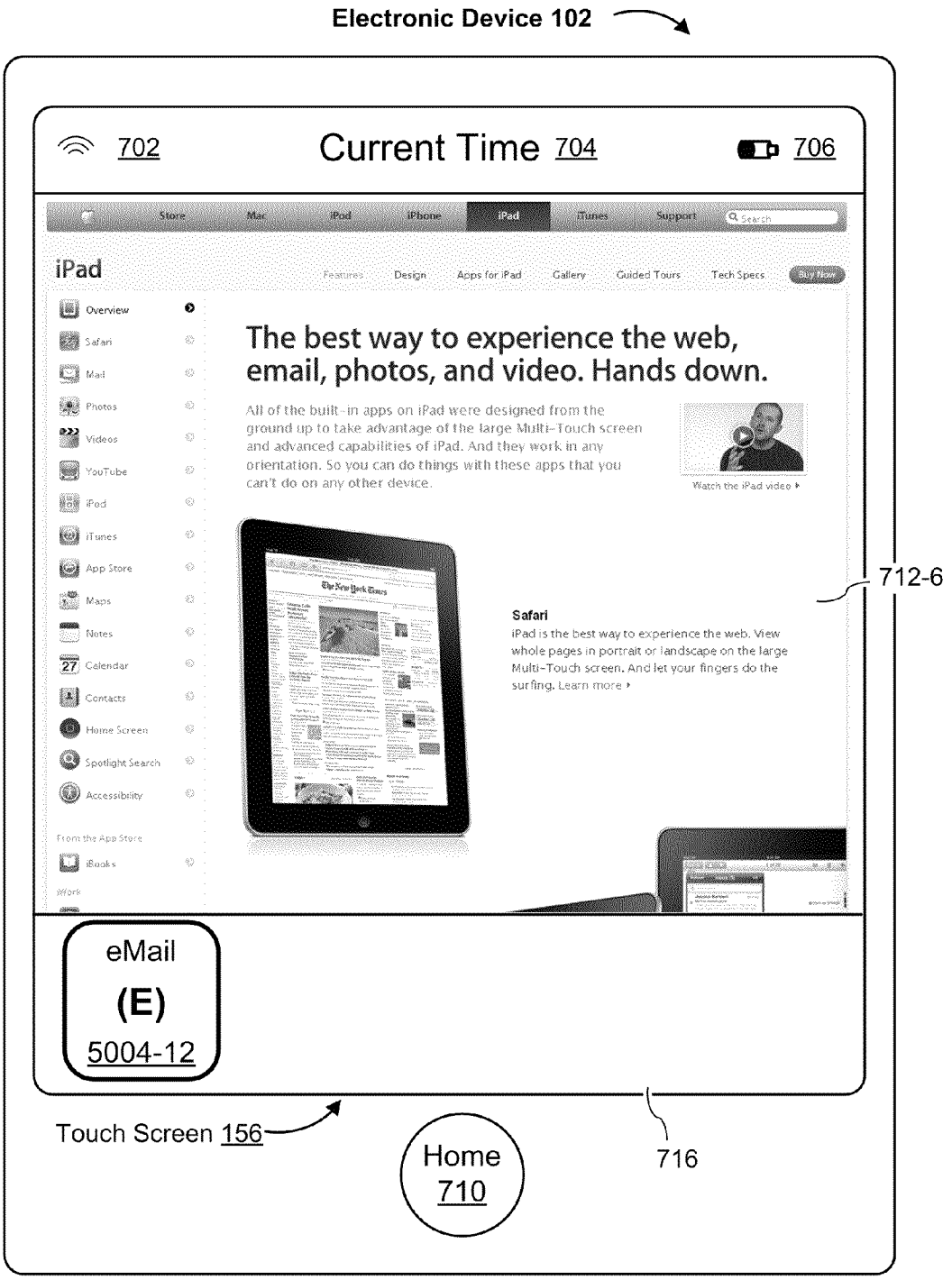
712-6
Weather
(W)
5004-2
Map
(M)
5004-4
715
Notes
(N)
5004-6
iT
713
5004-8
Touch Screen 156
Home
710
716

Figure 7H


Electronic Device 102
702
Current Time 704
706
Store
Mac
iPod
iPhone
iPad
iTunes
Support
iPad
Features
Design
Apps for iPad
Gallery
Guided Tours
Tech Specs
Buy Now
Overview
Safari
Mail
Photos
Videos
YouTube
iPod
iTunes
App Store
Maps
Notes
Calendar
Contacts
Home Screen
Spotlight Search
Accessibility
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iBooks
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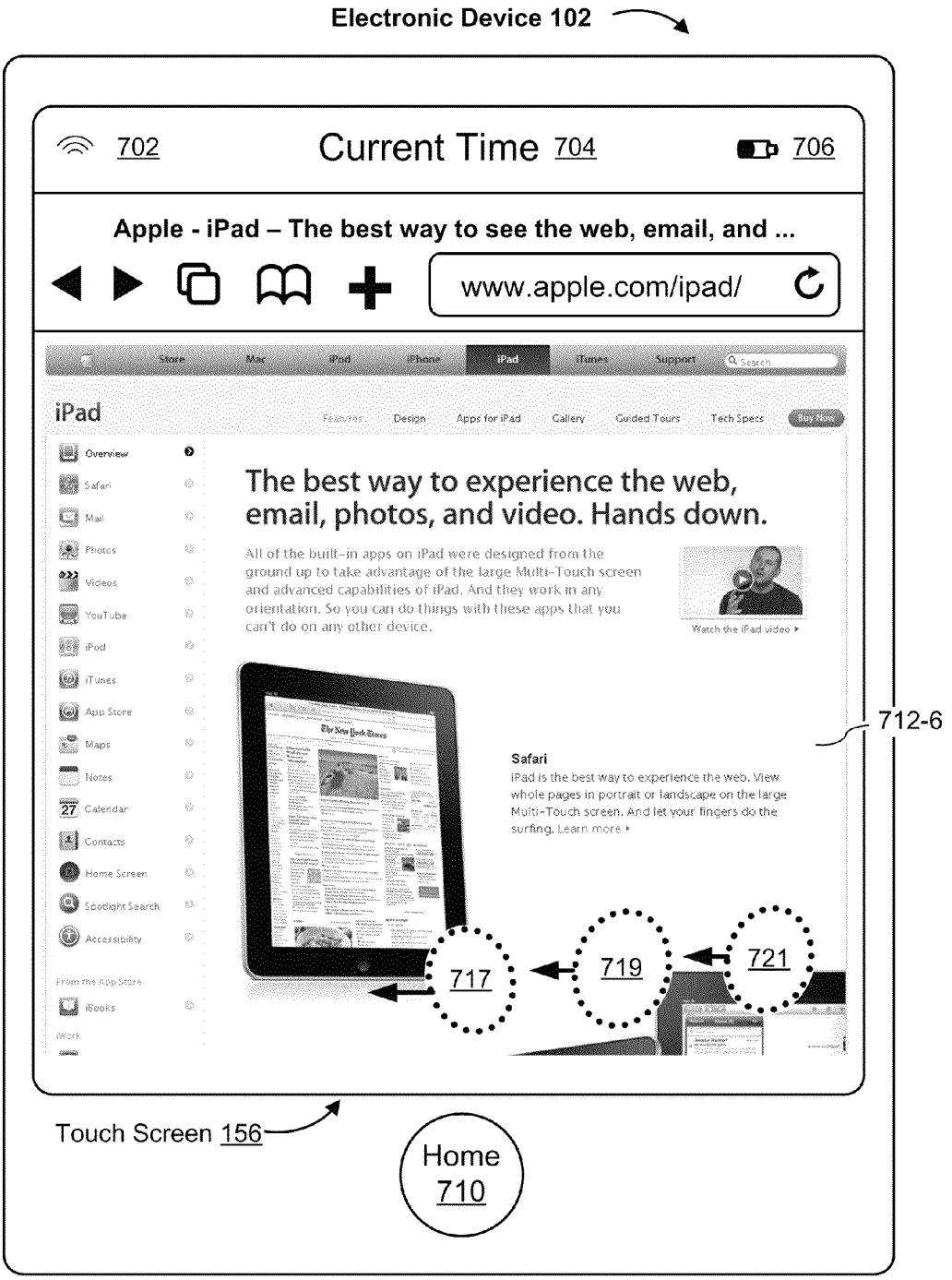
712-6
eMail
(E)
5004-12
Touch Screen 156
Home
710
716

Figure 7I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702
Current Time 704
706
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iPad
Features
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Buy Now
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iTunes
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Notes
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Contacts
Home Screen
Spotlight Search
Accessibility
From the App Store
iBooks
The best way to experience the web, email, photos, and video. Hands down.
All of the built-in apps on iPad were designed from the ground up to take advantage of the large Multi-Touch screen and advanced capabilities of iPad. And they work in any orientation. So you can do things with these apps that you can't do on any other device.
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712-6
Safari
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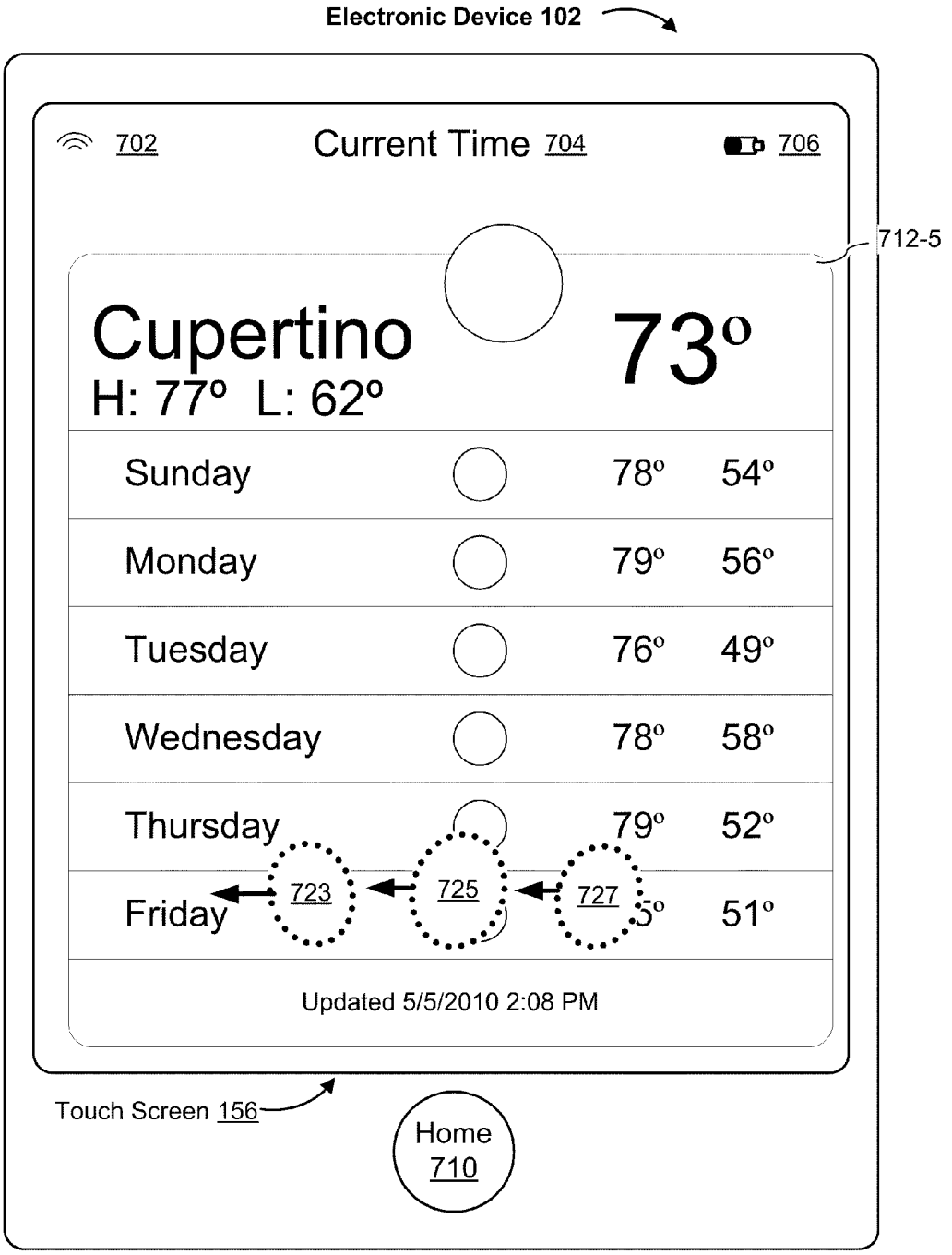
717
719
721
Touch Screen 156
Home 710

Figure 7J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Current Time 704
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712-5
Cupertino
H: 77° L: 62°
73°
Sunday 78° 54°
Monday 79° 56°
Tuesday 76° 49°
Wednesday 78° 58°
Thursday 79° 52°
Friday 51°
723
725
727
Updated 5/5/2010 2:08 PM
Touch Screen 156
Home
710

Figure 7K

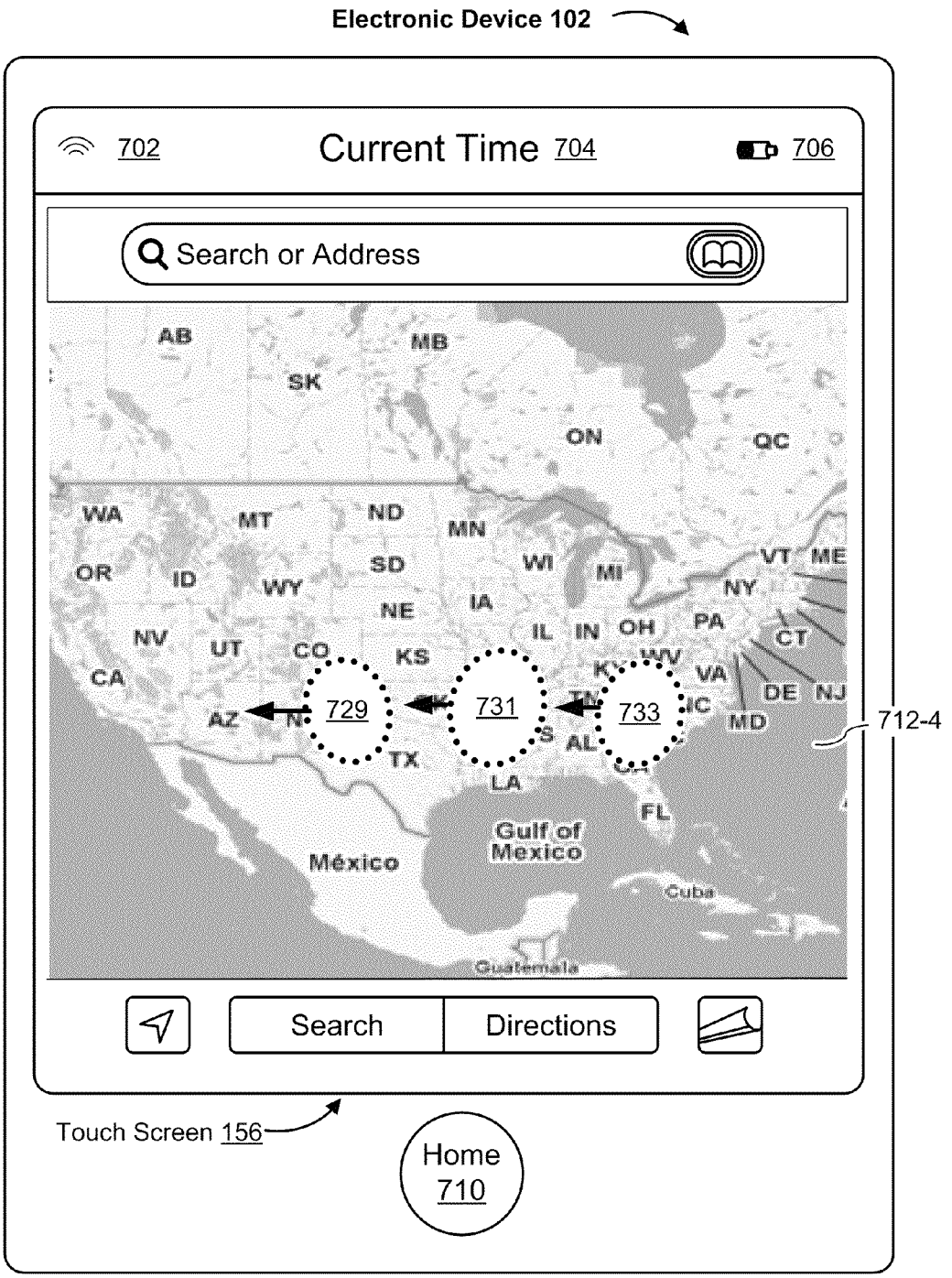

Electronic Device 102
702
Current Time 704
706
Search or Address
AB
MB
SK
ON
QC
WA
MT
ND
MN
OR
ID
WY
SD
WI
MI
VT
ME
NY
NE
IA
NV
UT
CO
KS
IL
IN
OH
PA
CT
CA
VA
DE
NJ
AZ
729
731
733
MD
712-4
TX
AL
LA
FL
Gulf of Mexico
México
Cuba
Guatemala
Search
Directions
Touch Screen 156
Home 710

Figure 7L

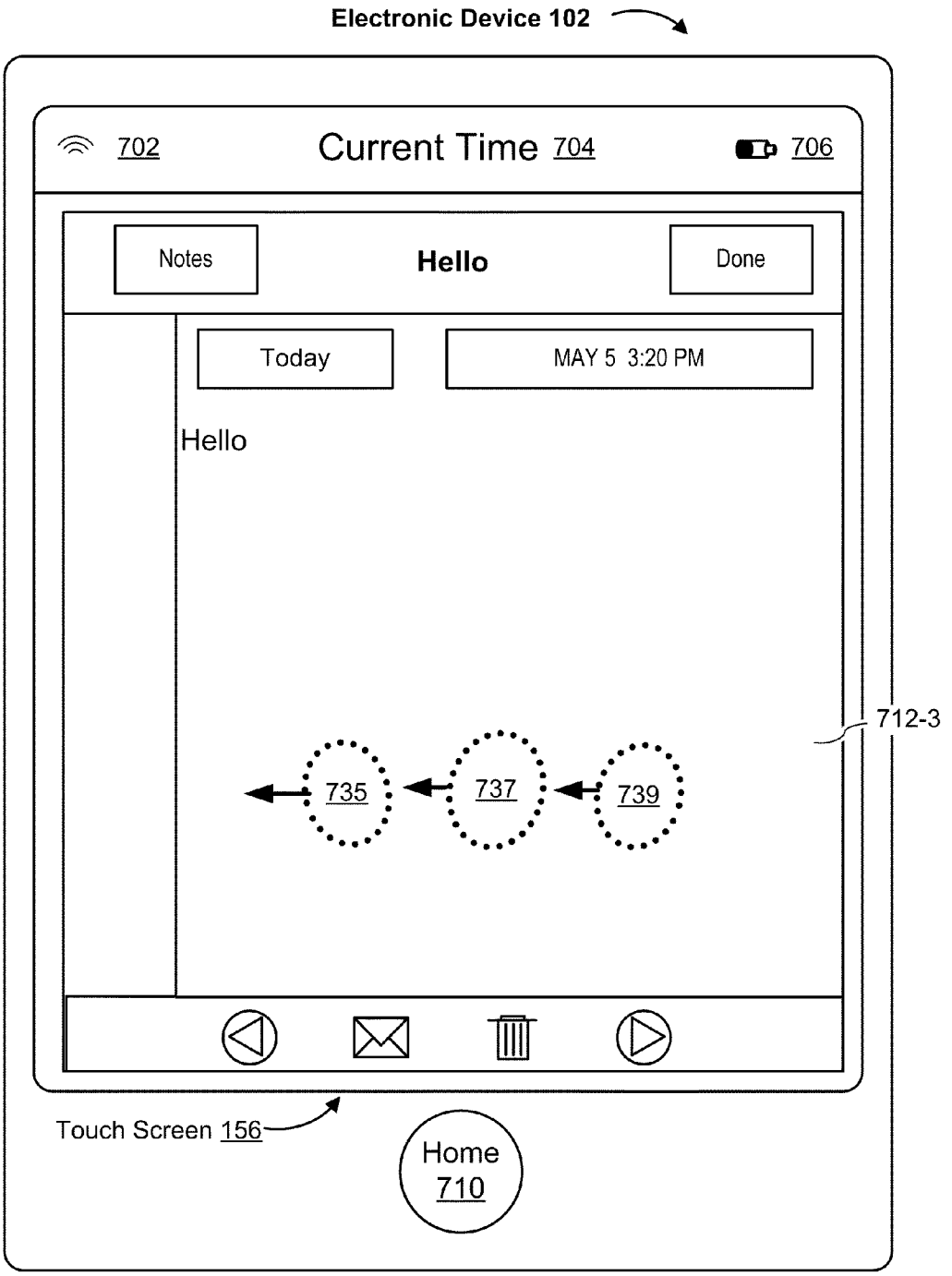

Electronic Device 102
702
Current Time 704
706
Notes
Hello
Done
Today
MAY 5 3:20 PM
Hello
712-3
735
737
739
Touch Screen 156
Home
710

Figure 7M

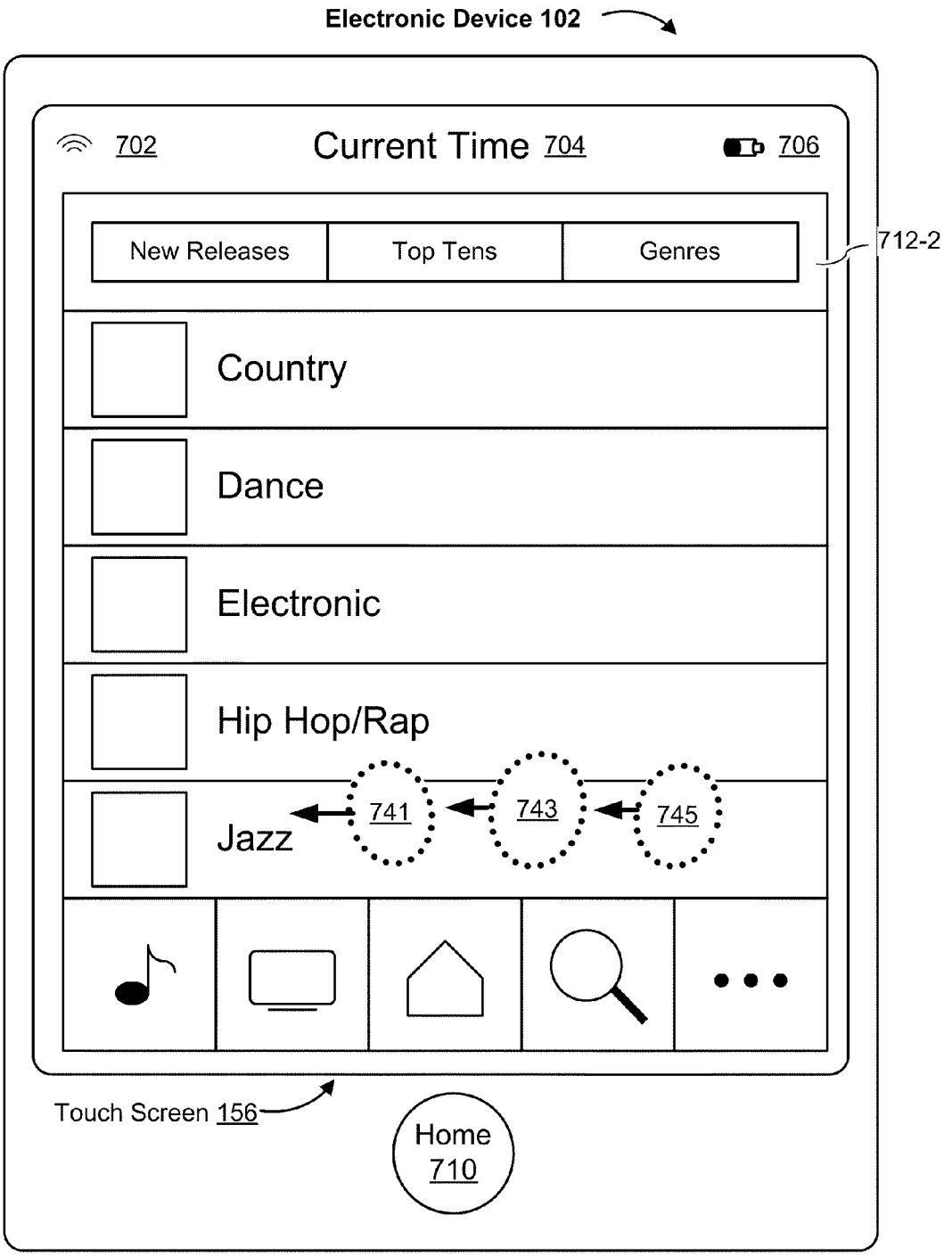

Electronic Device 102
702
Current Time 704
706
New Releases
Top Tens
Genres
712-2
Country
Dance
Electronic
Hip Hop/Rap
Jazz
741
743
745
Touch Screen 156
Home
710

Figure 7N

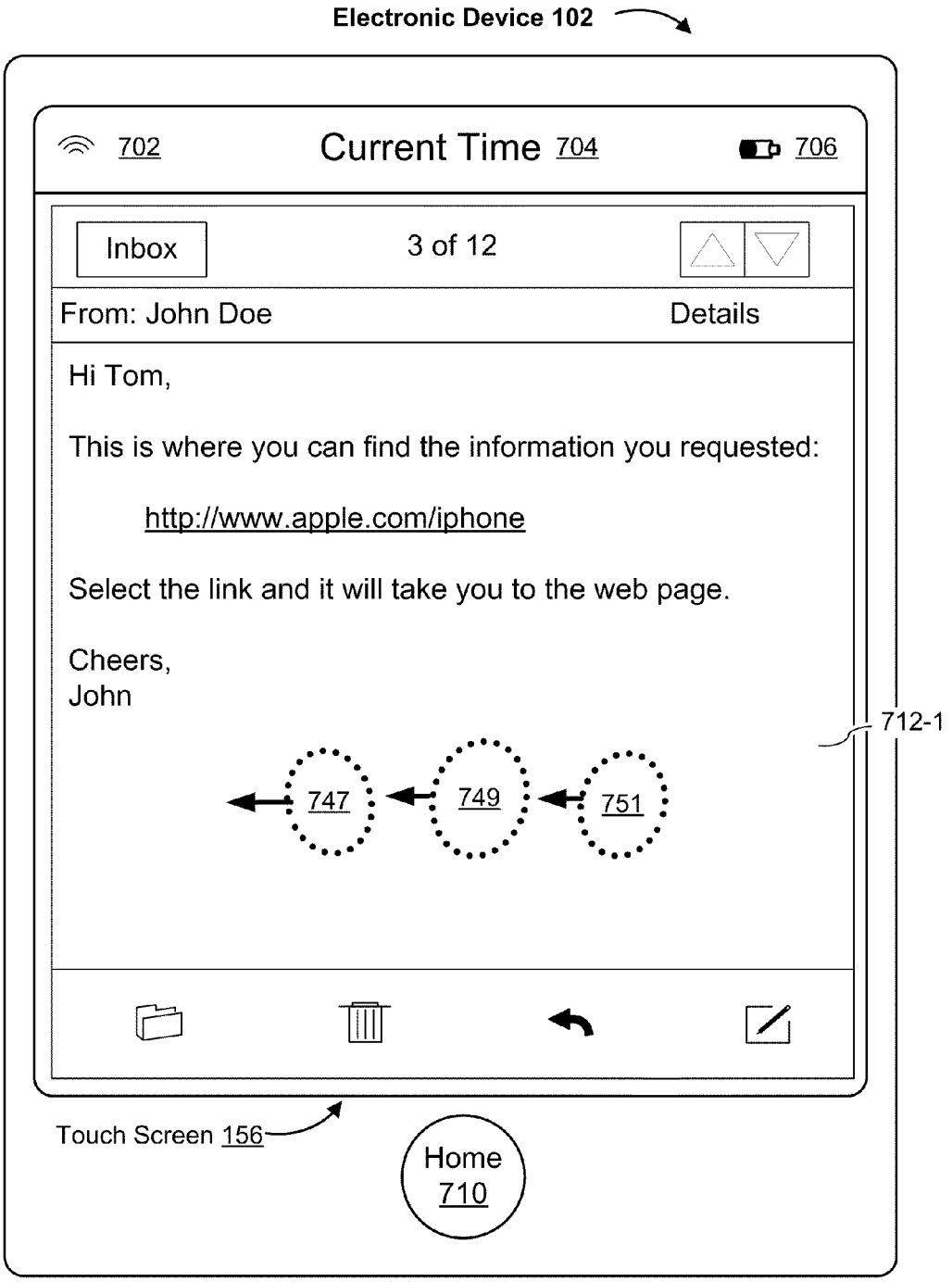
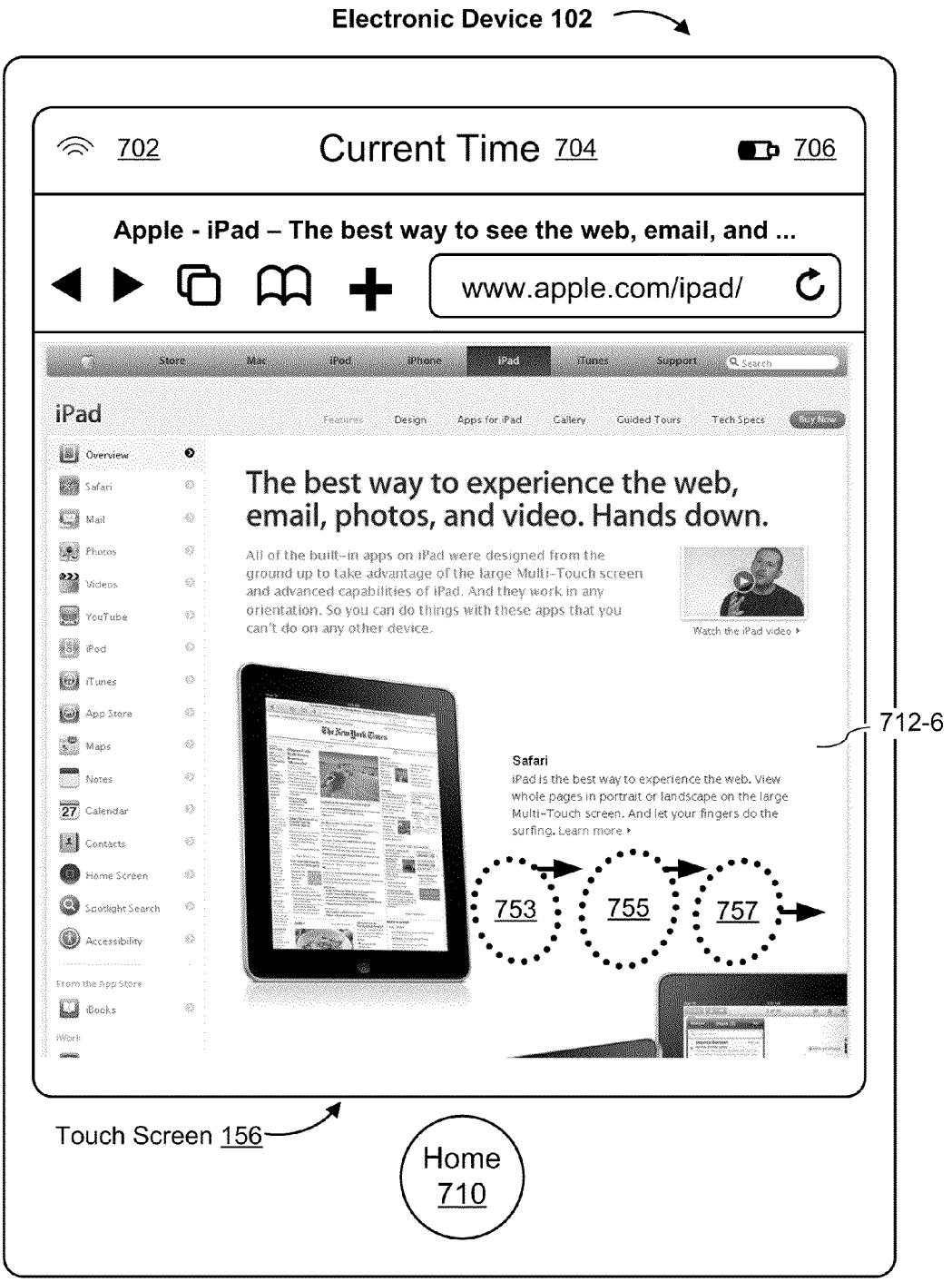

Electronic Device 102
702
Current Time 704
706
Inbox
3 of 12
From: John Doe
Details
Hi Tom,
This is where you can find the information you requested:
http://www.apple.com/iphone
Select the link and it will take you to the web page.
Cheers,
John
712-1
747
749
751
Touch Screen 156
Home
710

Figure 7O


Electronic Device 102
702
Current Time 704
706
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Guided Tours
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Overview
Safari
Mail
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Videos
YouTube
iPod
iTunes
App Store
Maps
Notes
Calendar
Contacts
Home Screen
Spotlight Search
Accessibility
From the App Store
iBooks
The best way to experience the web, email, photos, and video. Hands down.
All of the built-in apps on iPad were designed from the ground up to take advantage of the large Multi-Touch screen and advanced capabilities of iPad. And they work in any orientation. So you can do things with these apps that you can't do on any other device.
Watch the iPad video
Safari
iPad is the best way to experience the web. View whole pages in portrait or landscape on the large Multi-Touch screen. And let your fingers do the surfing. Learn more
753
755
757
712-6
Touch Screen 156
Home
710

Figure 7P

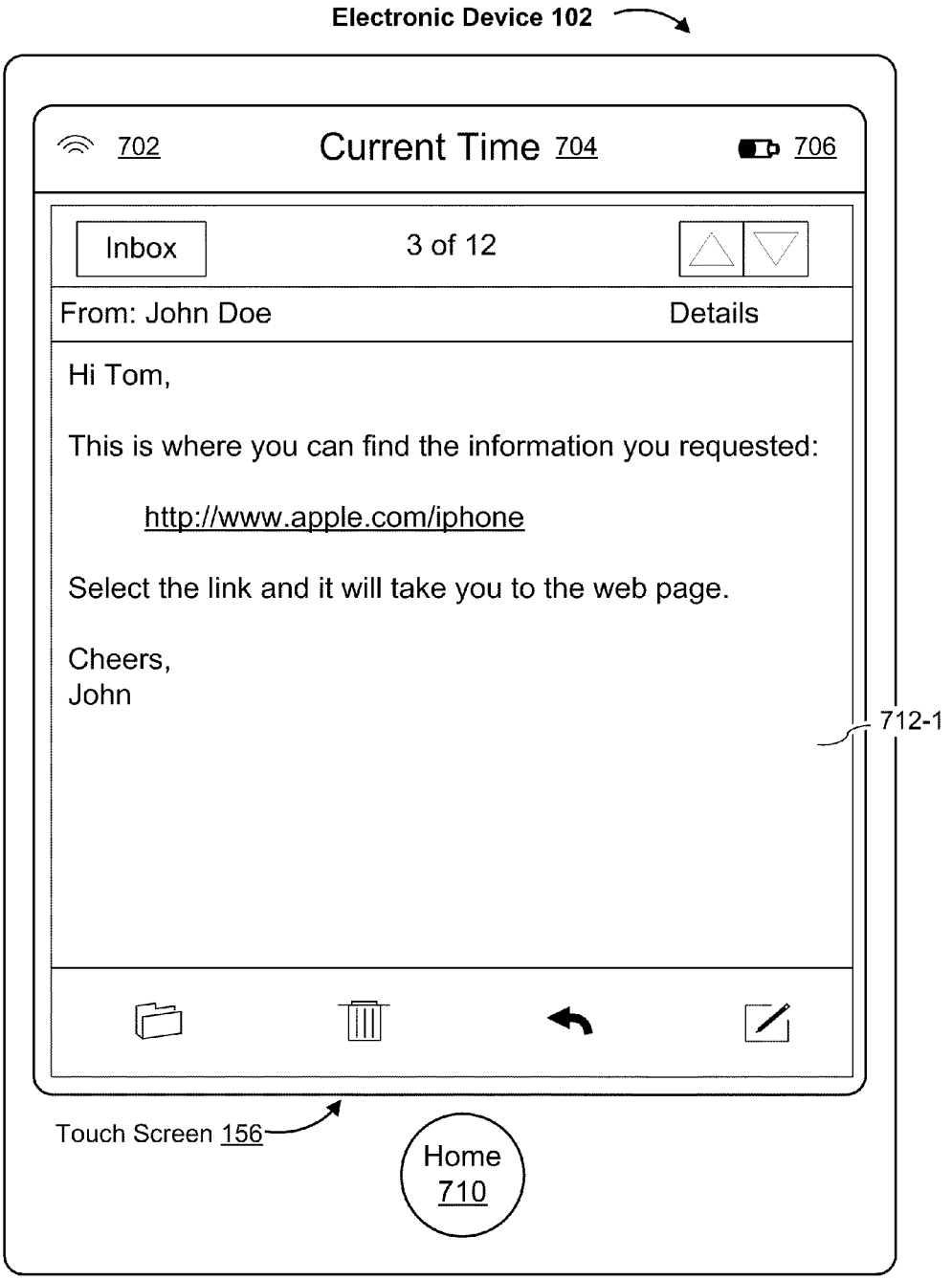
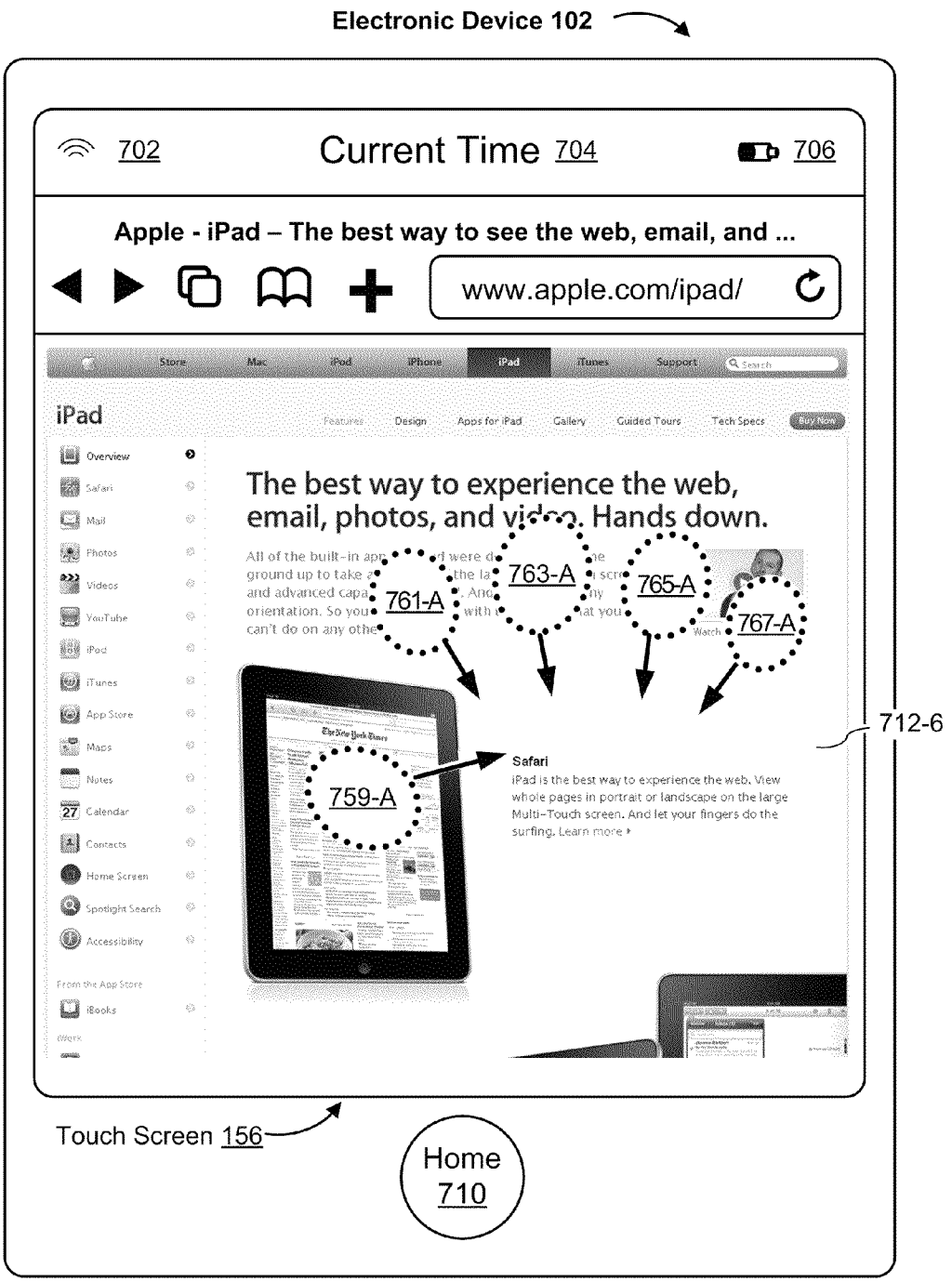

Electronic Device 102
702
Current Time 704
706
Inbox
3 of 12
From: John Doe
Details
Hi Tom,
This is where you can find the information you requested:
http://www.apple.com/iphone
Select the link and it will take you to the web page.
Cheers,
John
712-1
Touch Screen 156
Home
710

Figure 7Q


Electronic Device 102
702
Current Time 704
706
Apple - iPad – The best way to see the web, email, and ...
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iPad
The best way to experience the web, email, photos, and video. Hands down.
761-A
763-A
765-A
767-A
759-A
Safari
712-6
Touch Screen 156
Home 710

Figure 7R

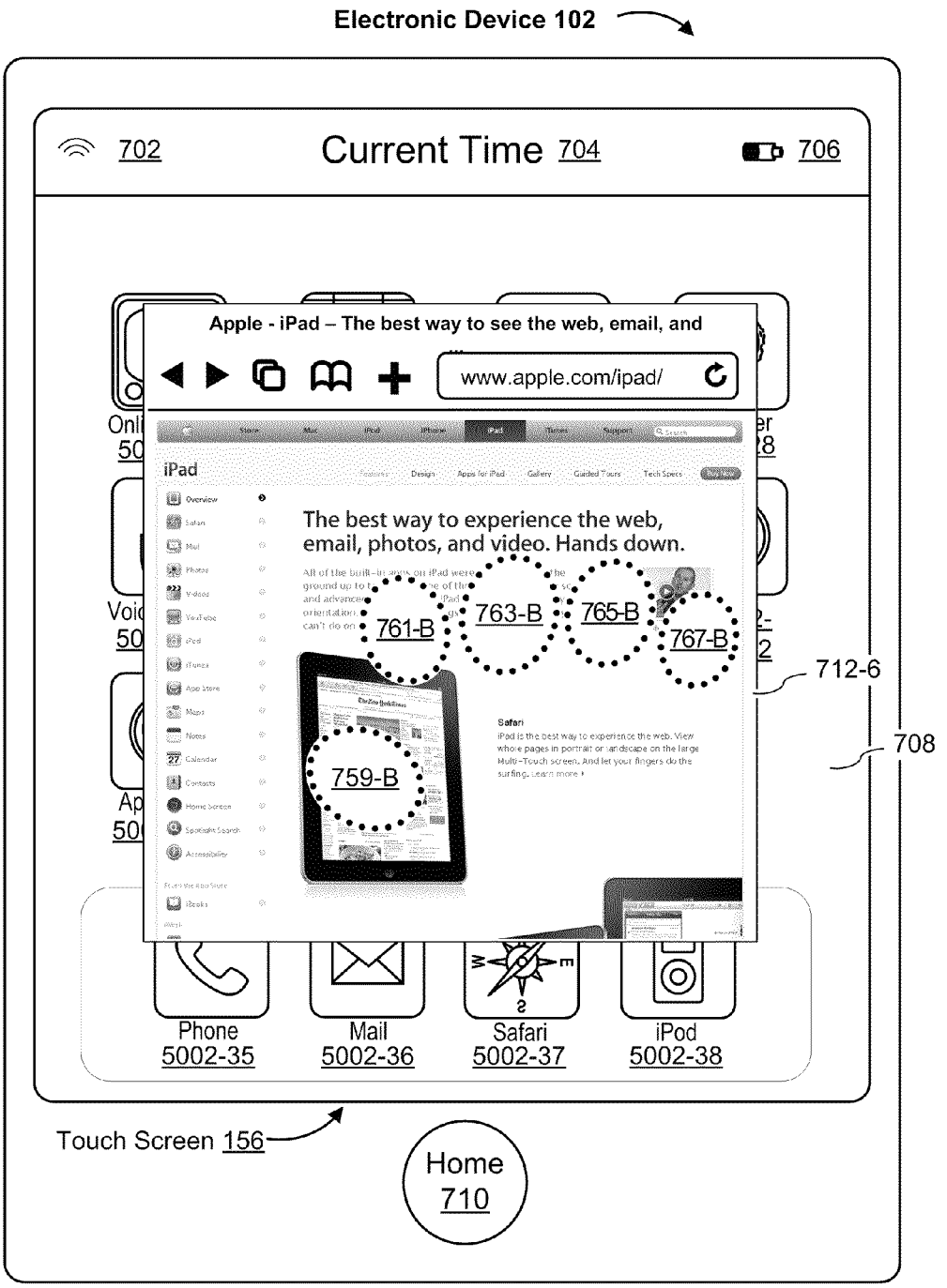
Electronic Device 102
702
Current Time 704
706
Apple - iPad – The best way to see the web, email, and
www.apple.com/ipad/
iPad
The best way to experience the web, email, photos, and video. Hands down.
761-B
763-B
765-B
767-B
759-B
712-6
708
Phone 5002-35
Mail 5002-36
Safari 5002-37
iPod 5002-38
Touch Screen 156
Home 710

Figure 7S

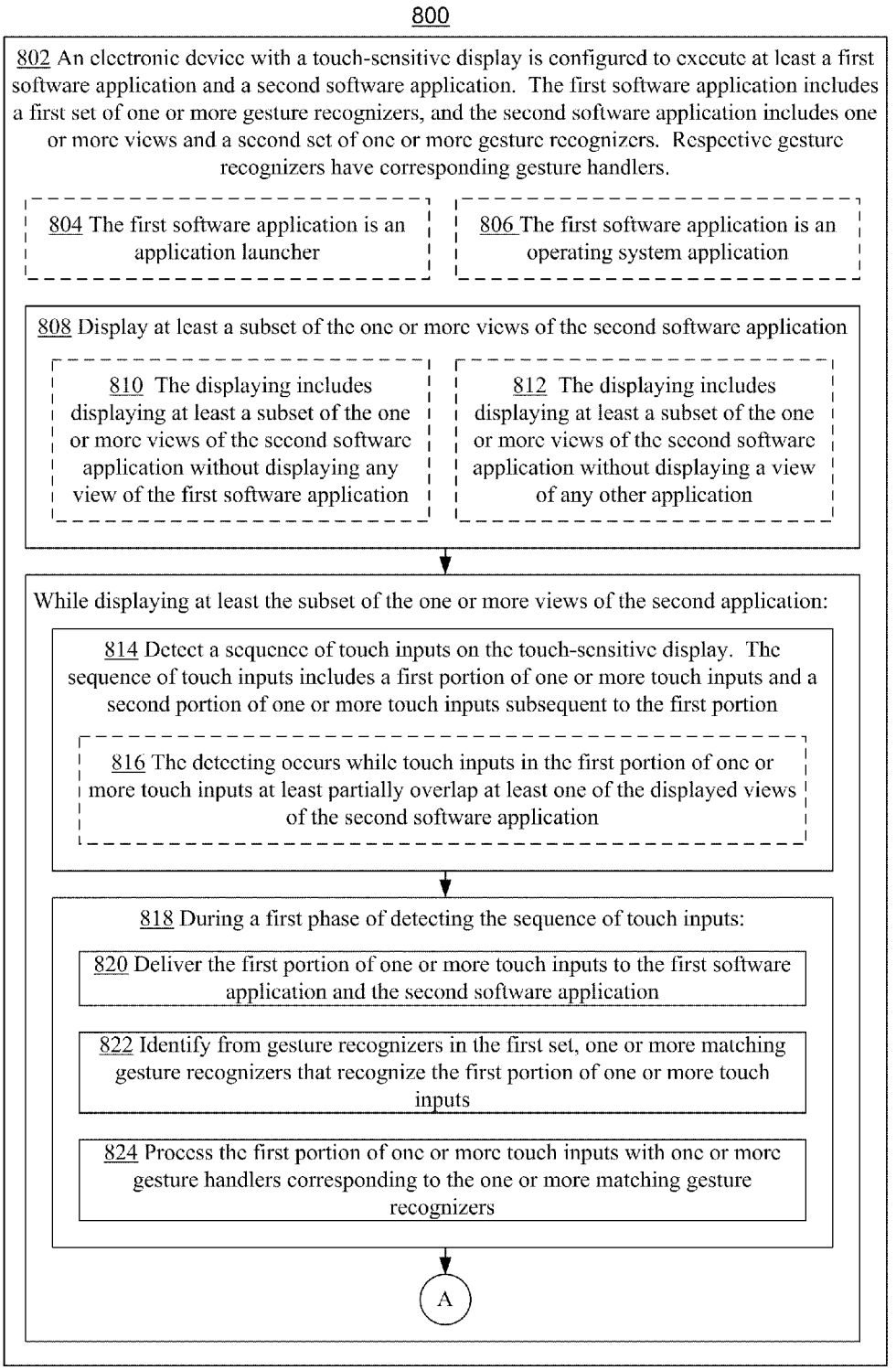
800
802 An electronic device with a touch-sensitive display is configured to execute at least a first software application and a second software application. The first software application includes a first set of one or more gesture recognizers, and the second software application includes one or more views and a second set of one or more gesture recognizers. Respective gesture recognizers have corresponding gesture handlers.
804 The first software application is an application launcher
806 The first software application is an operating system application
808 Display at least a subset of the one or more views of the second software application
810 The displaying includes displaying at least a subset of the one or more views of the second software application without displaying any view of the first software application
812 The displaying includes displaying at least a subset of the one or more views of the second software application without displaying a view of any other application
While displaying at least the subset of the one or more views of the second application:
814 Detect a sequence of touch inputs on the touch-sensitive display. The sequence of touch inputs includes a first portion of one or more touch inputs and a second portion of one or more touch inputs subsequent to the first portion
816 The detecting occurs while touch inputs in the first portion of one or more touch inputs at least partially overlap at least one of the displayed views of the second software application
818 During a first phase of detecting the sequence of touch inputs:
820 Deliver the first portion of one or more touch inputs to the first software application and the second software application
822 Identify from gesture recognizers in the first set, one or more matching gesture recognizers that recognize the first portion of one or more touch inputs
824 Process the first portion of one or more touch inputs with one or more gesture handlers corresponding to the one or more matching gesture recognizers
A

Figure 8A

A
826 During a second phase of detecting the sequence of touch inputs, subsequent to the first phase:
deliver the second portion of one or more touch inputs to the first software application without delivering the second portion of one or more touch inputs to the second software application;
identify from the one or more matching gesture recognizers a second matching gesture recognizer that recognizes the sequence of touch inputs; and
process the sequence of touch inputs with a gesture handler corresponding to the respective matching gesture recognizer.
828 Processing the sequence of touch inputs with the gesture handler corresponding to the respective matching gesture recognizer includes displaying one or more views of the first software application
830 Processing the sequence of touch inputs with the gesture handler corresponding to the respective matching gesture recognizer includes replacing the display of the one or more views of the second software application with display of one or more views of the first software application
832 The electronic device concurrently executes the first software application, the second software application, and a third software application. Processing the sequence of touch inputs with the gesture handler corresponding to the respective matching gesture recognizer includes replacing the one or more displayed views of the second software application with one or more views of the third software application.
834 Processing the sequence of touch inputs with the gesture handler corresponding to the respective matching gesture recognizer includes:
displaying in a first predefined area of the touch-sensitive display a group of open application icons that correspond to at least some of a plurality of concurrently open applications; and
concurrently displaying at least a subset of the one or more views of the second software application.

Figure 8B

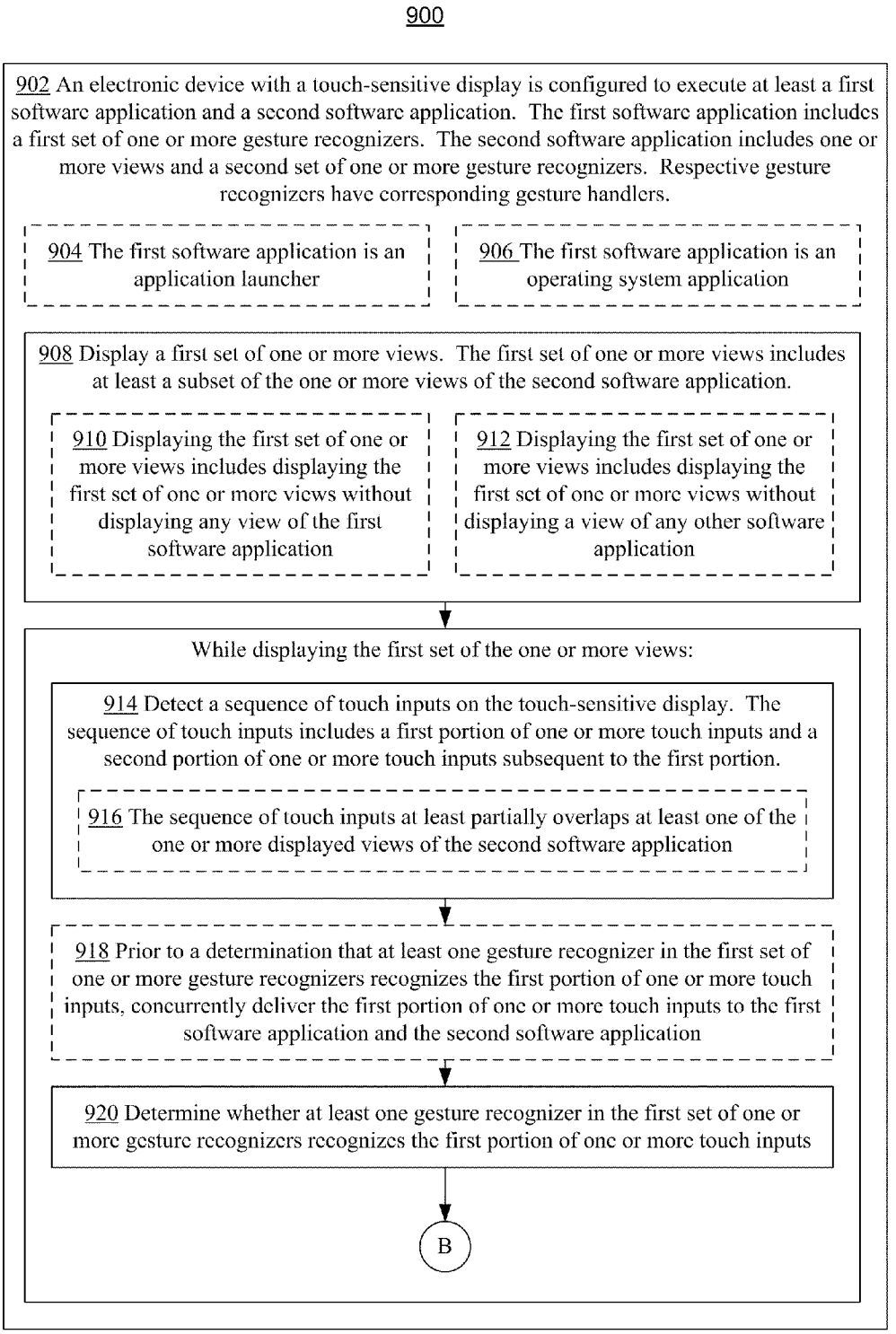
900
902 An electronic device with a touch-sensitive display is configured to execute at least a first software application and a second software application. The first software application includes a first set of one or more gesture recognizers. The second software application includes one or more views and a second set of one or more gesture recognizers. Respective gesture recognizers have corresponding gesture handlers.
904 The first software application is an application launcher
906 The first software application is an operating system application
908 Display a first set of one or more views. The first set of one or more views includes at least a subset of the one or more views of the second software application.
910 Displaying the first set of one or more views includes displaying the first set of one or more views without displaying any view of the first software application
912 Displaying the first set of one or more views includes displaying the first set of one or more views without displaying a view of any other software application
While displaying the first set of the one or more views:
914 Detect a sequence of touch inputs on the touch-sensitive display. The sequence of touch inputs includes a first portion of one or more touch inputs and a second portion of one or more touch inputs subsequent to the first portion.
916 The sequence of touch inputs at least partially overlaps at least one of the one or more displayed views of the second software application
918 Prior to a determination that at least one gesture recognizer in the first set of one or more gesture recognizers recognizes the first portion of one or more touch inputs, concurrently deliver the first portion of one or more touch inputs to the first software application and the second software application
920 Determine whether at least one gesture recognizer in the first set of one or more gesture recognizers recognizes the first portion of one or more touch inputs
B

Figure 9A

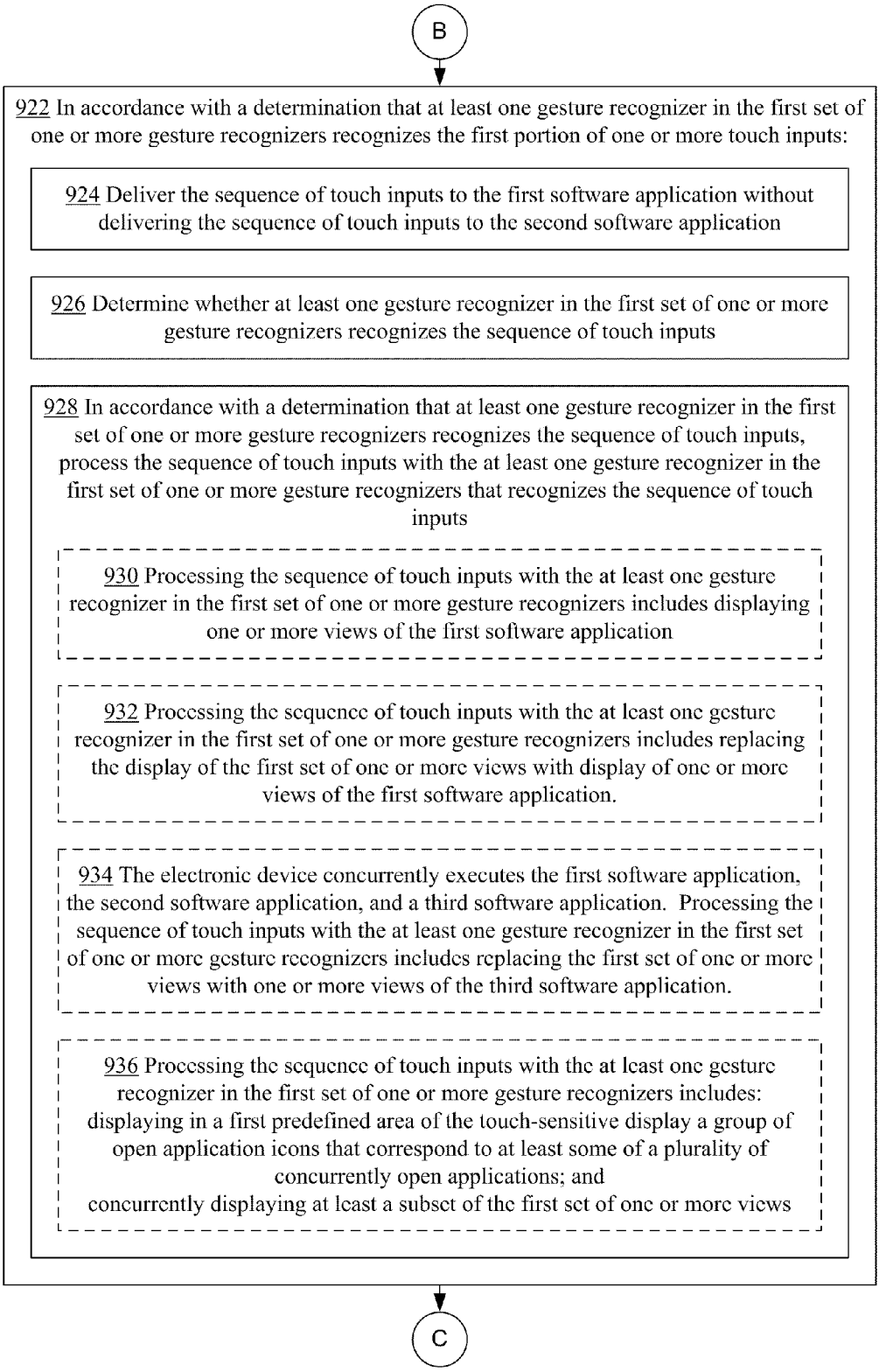
B
922 In accordance with a determination that at least one gesture recognizer in the first set of one or more gesture recognizers recognizes the first portion of one or more touch inputs:
924 Deliver the sequence of touch inputs to the first software application without delivering the sequence of touch inputs to the second software application
926 Determine whether at least one gesture recognizer in the first set of one or more gesture recognizers recognizes the sequence of touch inputs
928 In accordance with a determination that at least one gesture recognizer in the first set of one or more gesture recognizers recognizes the sequence of touch inputs, process the sequence of touch inputs with the at least one gesture recognizer in the first set of one or more gesture recognizers that recognizes the sequence of touch inputs
930 Processing the sequence of touch inputs with the at least one gesture recognizer in the first set of one or more gesture recognizers includes displaying one or more views of the first software application
932 Processing the sequence of touch inputs with the at least one gesture recognizer in the first set of one or more gesture recognizers includes replacing the display of the first set of one or more views with display of one or more views of the first software application.
934 The electronic device concurrently executes the first software application, the second software application, and a third software application. Processing the sequence of touch inputs with the at least one gesture recognizer in the first set of one or more gesture recognizers includes replacing the first set of one or more views with one or more views of the third software application.
936 Processing the sequence of touch inputs with the at least one gesture recognizer in the first set of one or more gesture recognizers includes:
displaying in a first predefined area of the touch-sensitive display a group of open application icons that correspond to at least some of a plurality of concurrently open applications; and
concurrently displaying at least a subset of the first set of one or more views
C

**Figure 9B**

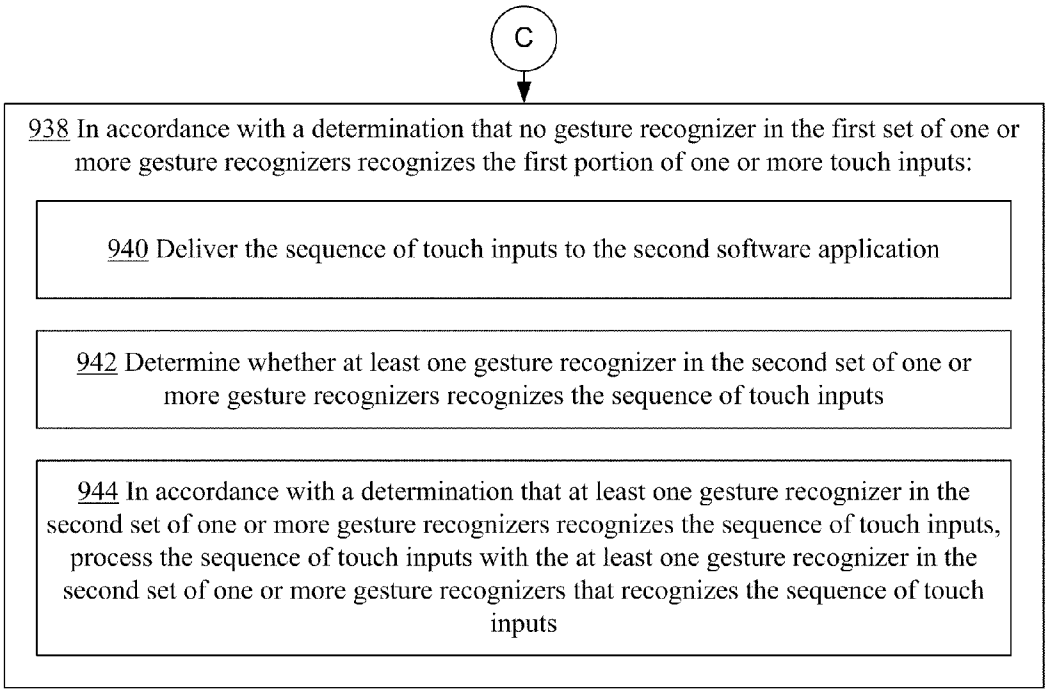
C
938 In accordance with a determination that no gesture recognizer in the first set of one or more gesture recognizers recognizes the first portion of one or more touch inputs:
940 Deliver the sequence of touch inputs to the second software application
942 Determine whether at least one gesture recognizer in the second set of one or more gesture recognizers recognizes the sequence of touch inputs
944 In accordance with a determination that at least one gesture recognizer in the second set of one or more gesture recognizers recognizes the sequence of touch inputs, process the sequence of touch inputs with the at least one gesture recognizer in the second set of one or more gesture recognizers that recognizes the sequence of touch inputs

Figure 9C

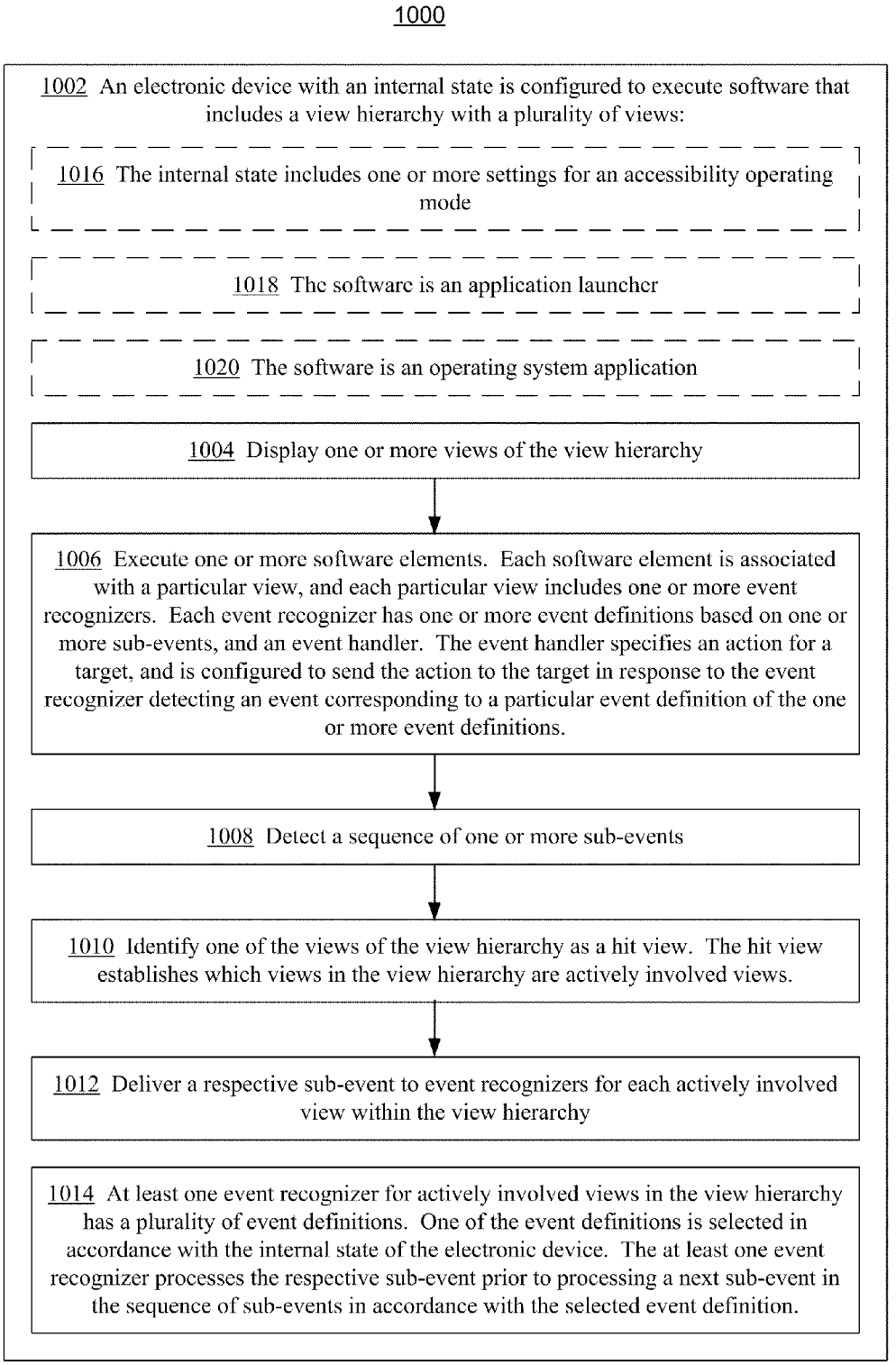
1000
1002 An electronic device with an internal state is configured to execute software that includes a view hierarchy with a plurality of views:
1016 The internal state includes one or more settings for an accessibility operating mode
1018 The software is an application launcher
1020 The software is an operating system application
1004 Display one or more views of the view hierarchy
1006 Execute one or more software elements. Each software element is associated with a particular view, and each particular view includes one or more event recognizers. Each event recognizer has one or more event definitions based on one or more sub-events, and an event handler. The event handler specifies an action for a target, and is configured to send the action to the target in response to the event recognizer detecting an event corresponding to a particular event definition of the one or more event definitions.
1008 Detect a sequence of one or more sub-events
1010 Identify one of the views of the view hierarchy as a hit view. The hit view establishes which views in the view hierarchy are actively involved views.
1012 Deliver a respective sub-event to event recognizers for each actively involved view within the view hierarchy
1014 At least one event recognizer for actively involved views in the view hierarchy has a plurality of event definitions. One of the event definitions is selected in accordance with the internal state of the electronic device. The at least one event recognizer processes the respective sub-event prior to processing a next sub-event in the sequence of sub-events in accordance with the selected event definition.

**Figure 10A**

1014 At least one event recognizer for actively involved views in the view hierarchy has a plurality of event definitions. One of the event definitions is selected in accordance with the internal state of the electronic device. The at least one event recognizer processes the respective sub-event prior to processing a next sub-event in the sequence of sub-events in accordance with the selected event definition.

1020 The plurality of event definitions includes a first event definition corresponding to a first swipe gesture with a first number of fingers and a second event definition corresponding to a second swipe gesture with a second number of fingers distinct from the first number of fingers.

1022 A respective definition of the plurality of event definitions is selected for a respective event recognizer in accordance with the internal state of the electronic device and a determination that the respective event definition does not correspond to an event definition of any event recognizer for the actively involved views other than the respective event recognizer.

1024 Two or more event recognizers for actively involved views in the view hierarchy each have a respective plurality of event definitions, and a respective event definition of the respective plurality of event definitions is selected for a respective event recognizer in accordance with the internal state of the electronic device and a determination that the respective event definition does not correspond to any event definition selected for any event recognizer with the plurality of event definitions other than the respective event recognizer

1026 Processing the respective sub-event in accordance with the selected event definition includes displaying one or more views of a first software application distinct from the software that includes the view hierarchy

1028 The at least one event recognizer processes the respective sub-event by replacing the display of the one or more views of the view hierarchy with display of one or more views of a first software application distinct from the software that includes the view hierarchy

1030 The at least one event recognizer processes the respective sub-event by: displaying in a first predefined area of a touch-sensitive display in the electronic device a group of open application icons that correspond to at least some of a plurality of concurrently open applications; and concurrently displaying at least a subset of the one or more views of the view hierarchy

**Figure 10B**

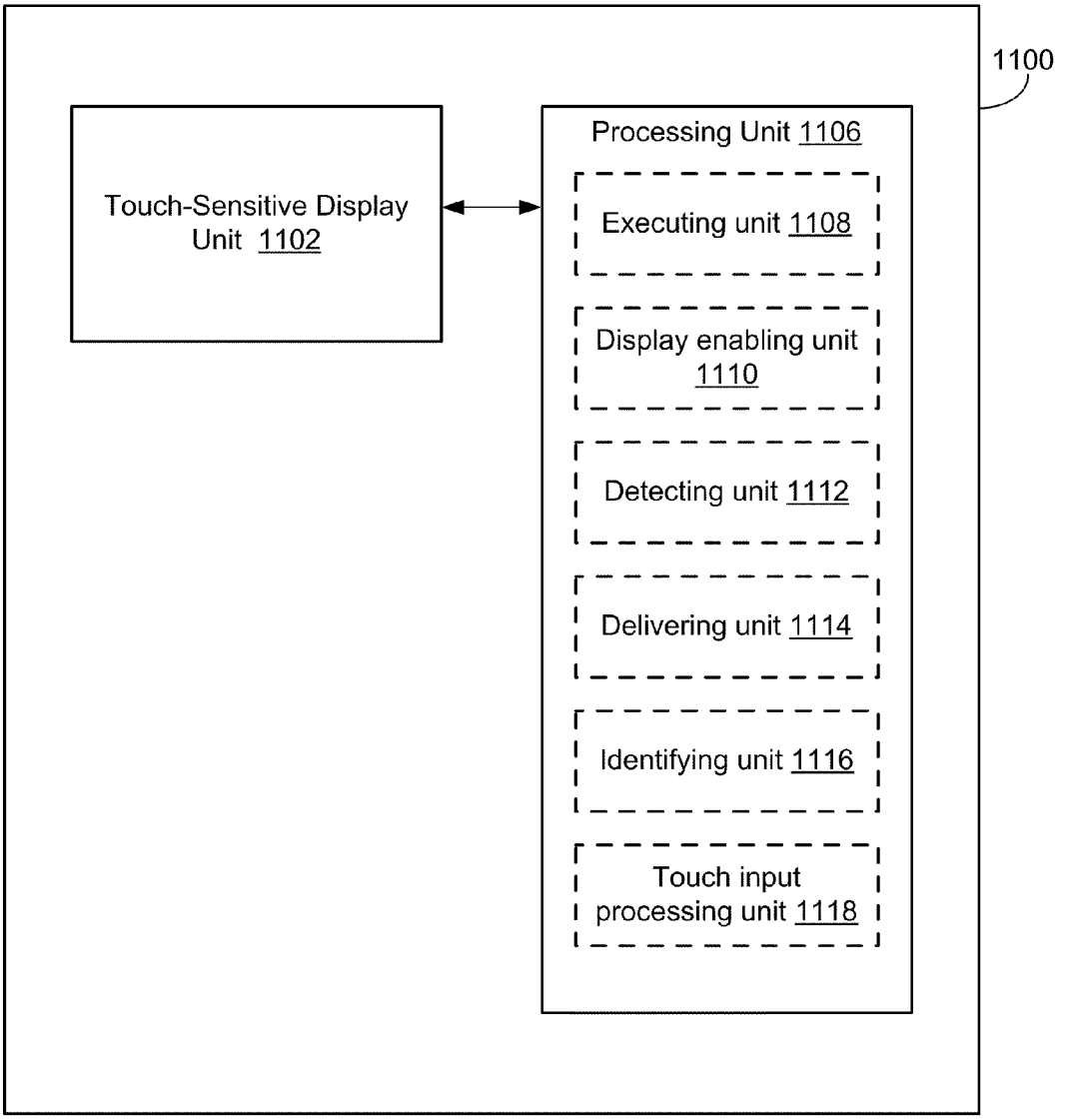
1100
Touch-Sensitive Display Unit 1102
Processing Unit 1106
Executing unit 1108
Display enabling unit 1110
Detecting unit 1112
Delivering unit 1114
Identifying unit 1116
Touch input processing unit 1118

Figure 11

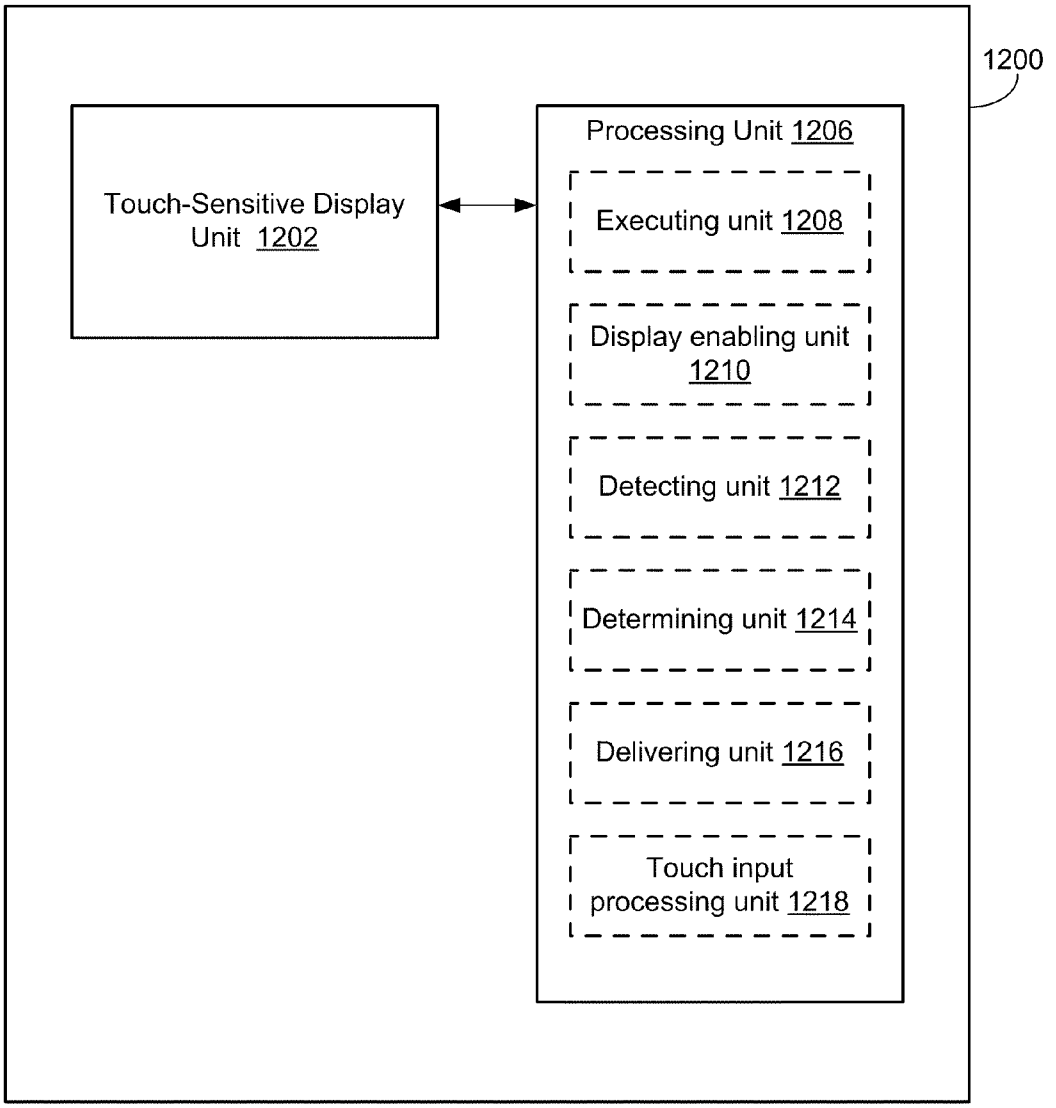
1200
Touch-Sensitive Display Unit 1202
Processing Unit 1206
Executing unit 1208
Display enabling unit 1210
Detecting unit 1212
Determining unit 1214
Delivering unit 1216
Touch input processing unit 1218

Figure 12

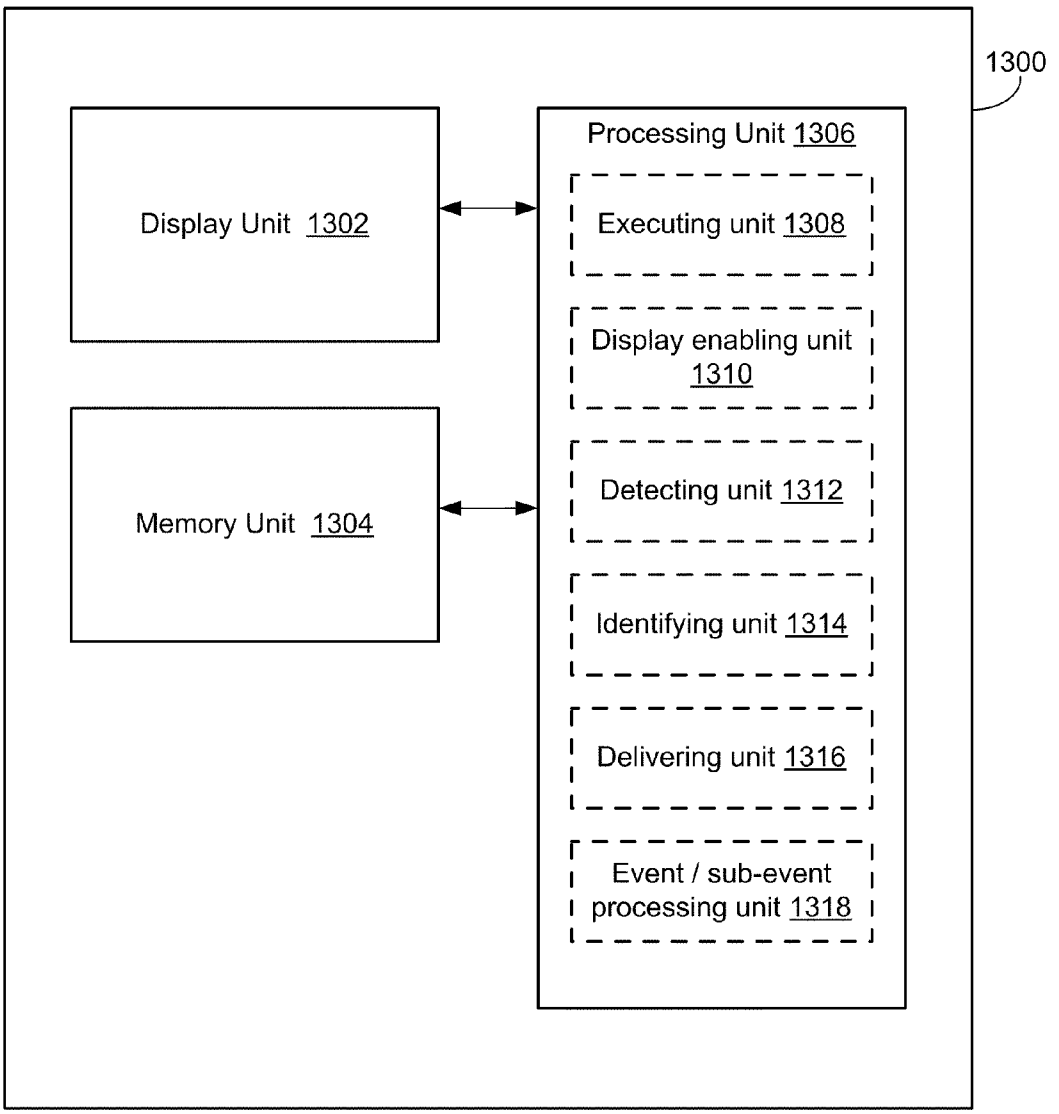
1300
Display Unit 1302
Memory Unit 1304
Processing Unit 1306
Executing unit 1308
Display enabling unit 1310
Detecting unit 1312
Identifying unit 1314
Delivering unit 1316
Event / sub-event processing unit 1318

Figure 13

# EVENT RECOGNITION

## RELATED APPLICATIONS

This application claims priority to U.S. Provisional Application Ser. No. 61/425,222, filed on Dec. 20, 2010, entitled "Event Recognition." This application is a continuation-in-part of: (A) U.S. patent application Ser. No. 12/566,660, filed Sep. 24, 2009, entitled "Event Recognition," which claims priority to U.S. Provisional Application Ser. No. 61/210,332, filed on Mar. 16, 2009, entitled "Event Recognition"; and (B) U.S. patent application Ser. No. 12/789,695, filed May 28, 2010, entitled "Gesture Recognizers with Delegates for Controlling and Modifying Gesture Recognition," which claims priority to U.S. Provisional Application Ser. No. 61/298,531, filed Jan. 26, 2010, entitled "Gesture Recognizers with Delegates for Controlling and Modifying Gesture Recognition." All of these applications are incorporated by reference herein in their entirety.

This application relates to U.S. patent application Ser. No. 13/077,524 filed Mar. 31, 2011, entitled "Device, Method, and Graphical User Interface for Navigation of Concurrently Open Software Applications". This application is incorporated by reference herein in its entirety.

This application relates to U.S. patent application Ser. No. 13/077,925, filed Mar. 31, 2011, entitled "Event Recognition"; and U.S. patent application Ser. No. 13/077,927, filed Mar. 31, 2011, entitled "Event Recognition". Both of these applications are incorporated by reference herein in their entirety.

## TECHNICAL FIELD

This relates generally to user interface processing, including but not limited to, apparatuses and methods for recognizing touch inputs.

## BACKGROUND

An electronic device typically includes a user interface that is used to interact with the computing device. The user interface may include a display and/or input devices such as a keyboard, mice, and touch-sensitive surfaces for interacting with various aspects of the user interface. In some devices with a touch-sensitive surface as an input device, a first set of touch-based gestures (e.g., two or more of: tap, double tap, horizontal swipe, vertical swipe, pinch, depinch, two finger swipe) are recognized as proper inputs in a particular context (e.g., in a particular mode of a first application), and other, different sets of touch-based gestures are recognized as proper inputs in other contexts (e.g., different applications and/or different modes or contexts within the first application). As a result, the software and logic required for recognizing and responding to touch-based gestures can become complex, and can require revision each time an application is updated or a new application is added to the computing device. These and similar issues may arise in user interfaces that utilize input sources other than touch-based gestures.

Thus, it would be desirable to have a comprehensive framework or mechanism for recognizing touch-based gestures and events, as well as gestures and events from other input sources, that is easily adaptable to virtually all contexts or modes of all application programs on a computing device, and that requires little or no revision when an application is updated or a new application is added to the computing device.



## SUMMARY

To address the aforementioned drawbacks, some embodiments provide a method performed at an electronic device with a touch-sensitive display. The electronic device is configured to execute at least a first software application and a second software application. The first software application includes a first set of one or more gesture recognizers, and the second software application includes one or more views and a second set of one or more gesture recognizers. Respective gesture recognizers have corresponding gesture handlers. The method includes displaying at least a subset of the one or more views of the second software application, and while displaying at least the subset of the one or more views of the second software application, detecting a sequence of touch inputs on the touch-sensitive display. The sequence of touch inputs includes a first portion of one or more touch inputs and a second portion of one or more touch inputs subsequent to the first portion. The method also includes, during a first phase of detecting the sequence of touch inputs, delivering the first portion of one or more touch inputs to the first software application and the second software application, identifying from gesture recognizers in the first set one or more matching gesture recognizers that recognize the first portion of one or more touch inputs, and processing the first portion of one or more touch inputs with one or more gesture handlers corresponding to the one or more matching gesture recognizers.

In accordance with some embodiments, a method is performed at an electronic device with a touch-sensitive display. The electronic device is configured to execute at least a first software application and a second software application. The first software application includes a first set of one or more gesture recognizers, and the second software application includes one or more views and a second set of one or more gesture recognizers. Respective gesture recognizers have corresponding gesture handlers. The method includes displaying a first set of one or more views. The first set of one or more views includes at least a subset of the one or more views of the second software application. The method also includes, while displaying the first set of the one or more views, detecting a sequence of touch inputs on the touch-sensitive display. The sequence of touch inputs includes a first portion of one or more touch inputs and a second portion of one or more touch inputs subsequent to the first portion. The method includes determining whether at least one gesture recognizer in the first set of one or more gesture recognizers recognizes the first portion of one or more touch inputs. The method also includes, in accordance with a determination that at least one gesture recognizer in the first set of one or more gesture recognizers recognizes the first portion of one or more touch inputs, delivering the sequence of touch inputs to the first software application without delivering the sequence of touch inputs to the second software application, and determining whether at least one gesture recognizer in the first set of one or more gesture recognizers recognizes the sequence of touch inputs. The method furthermore includes, in accordance with a determination that at least one gesture recognizer in the first set of one or more gesture recognizers recognizes the sequence of touch inputs, processing the sequence of touch inputs with the at least one gesture recognizer in the first set of one or more gesture recognizers that recognizes the sequence of touch inputs. The method also includes, in accordance with a determination that no gesture recognizer in the first set of one or more gesture recognizers recognizes the first portion of one or more touch inputs, delivering the sequence of touch inputs to the second software application, and determining whether at least one gesture recognizer in the second set of

one or more gesture recognizers recognizes the sequence of touch inputs. The method furthermore includes, in accordance with a determination that at least one gesture recognizer in the second set of one or more gesture recognizers recognizes the sequence of touch inputs, processing the sequence of touch inputs with the at least one gesture recognizer in the second set of one or more gesture recognizers that recognizes the sequence of touch inputs.

In accordance with some embodiments, a method is performed at an electronic device with an internal state. The electronic device is configured to execute software that includes a view hierarchy with a plurality of views. The method includes displaying one or more views of the view hierarchy, and executing one or more software elements. Each software element is associated with a particular view, and each particular view includes one or more event recognizers. Each event recognizer has one or more event definitions based on one or more sub-events, and an event handler, which specifies an action for a target, and is configured to send the action to the target in response to the event recognizer detecting an event corresponding to a particular event definition of the one or more event definitions. The method also includes detecting a sequence of one or more sub-events, and identifying one of the views of the view hierarchy as a hit view. The hit view establishes which views in the view hierarchy are actively involved views. The method furthermore includes delivering a respective sub-event to event recognizers for each actively involved view within the view hierarchy. At least one event recognizer for actively involved views in the view hierarchy has a plurality of event definitions, and one in the plurality of event definitions is selected in accordance with the internal state of the electronic device. The at least one event recognizer processes the respective sub-event prior to processing a next sub-event in the sequence of sub-events in accordance with the selected event definition.

In accordance with some embodiments, a non-transitory computer readable storage medium stores one or more programs for execution by one of more processors of an electronic device. The one or more programs include one or more instructions, which when executed by the electronic device, cause the device to perform any of the methods described above.

In accordance with some embodiments, an electronic device with a touch-sensitive display includes one or more processors, and memory storing one or more programs for execution by the one or more processors. The one or more programs include instructions for implementing any of the methods described above.

In accordance with some embodiments, an electronic device with a touch-sensitive display includes means for implementing any of the methods described above.

In accordance with some embodiments, an information processing apparatus in a multifunction device with a touch-sensitive display includes means for implementing any of the methods described above.

In accordance with some embodiments, an electronic device includes a touch-sensitive display unit configured to receive touch inputs, and a processing unit coupled to the touch-sensitive display unit. The processing unit is configured to execute at least a first software application and a second software application. The first software application includes a first set of one or more gesture recognizers, and the second software application includes one or more views and a second set of one or more gesture recognizers. Respective gesture recognizers have corresponding gesture handlers. The processing unit is configured to: enable display of at least a subset of the one or more views of the second software application; and while displaying at least the subset of the one or more views of the second software application, detect a sequence of touch inputs on the touch-sensitive display unit. The sequence of touch inputs includes a first portion of one or more touch inputs and a second portion of one or more touch inputs subsequent to the first portion. The processing unit is configured to, during a first phase of detecting the sequence of touch inputs: deliver the first portion of one or more touch inputs to the first software application and the second software application; identify from gesture recognizers in the first set one or more matching gesture recognizers that recognize the first portion of one or more touch inputs; and process the first portion of one or more touch inputs with one or more gesture handlers corresponding to the one or more matching gesture recognizers.

In accordance with some embodiments, an electronic device includes a touch-sensitive display unit configured to receive touch inputs, and a processing unit coupled to the touch-sensitive display unit. The processing unit is configured to execute at least a first software application and a second software application. The first software application includes a first set of one or more gesture recognizers, and the second software application includes one or more views and a second set of one or more gesture recognizers. Respective gesture recognizers have corresponding gesture handlers. The processing unit is configured to enable display of a first set of one or more views. The first set of one or more views includes at least a subset of the one or more views of the second software application. The processing unit is configured to, while displaying the first set of the one or more views: detect a sequence of touch inputs on the touch-sensitive display unit (the sequence of touch inputs includes a first portion of one or more touch inputs and a second portion of one or more touch inputs subsequent to the first portion); and determine whether at least one gesture recognizer in the first set of one or more gesture recognizers recognizes the first portion of one or more touch inputs. The processing unit is configured to, in accordance with a determination that at least one gesture recognizer in the first set of one or more gesture recognizers recognizes the first portion of one or more touch inputs: deliver the sequence of touch inputs to the first software application without delivering the sequence of touch inputs to the second software application; and determine whether at least one gesture recognizer in the first set of one or more gesture recognizers recognizes the sequence of touch inputs. The processing unit is configured to, in accordance with a determination that at least one gesture recognizer in the first set of one or more gesture recognizers recognizes the sequence of touch inputs, process the sequence of touch inputs with the at least one gesture recognizer in the first set of one or more gesture recognizers that recognizes the sequence of touch inputs. The processing unit is configured to, in accordance with a determination that no gesture recognizer in the first set of one or more gesture recognizers recognizes the first portion of one or more touch inputs: deliver the sequence of touch inputs to the second software application; determine whether at least one gesture recognizer in the second set of one or more gesture recognizers recognizes the sequence of touch inputs; and in accordance with a determination that at least one gesture recognizer in the second set of one or more gesture recognizers recognizes the sequence of touch inputs, process the sequence of touch inputs with the at least one gesture recognizer in the second set of one or more gesture recognizers that recognizes the sequence of touch inputs.

In accordance with some embodiments, an electronic device includes: a display unit configured to display one or more views; a memory unit configured to store an internal

state; and a processing unit coupled to the display unit and the memory unit. The processing unit is configured to: execute software that includes a view hierarchy with a plurality of views; enable display of one or more views of the view hierarchy; and execute one or more software elements. Each software element is associated with a particular view, and each particular view includes one or more event recognizers. Each event recognizer has: one or more event definitions based on one or more sub-events, and an event handler. The event handler specifies an action for a target, and is configured to send the action to the target in response to the event recognizer detecting an event corresponding to a particular event definition of the one or more event definitions. The processing unit is configured to: detect a sequence of one or more sub-events; and identify one of the views of the view hierarchy as a hit view. The hit view establishes which views in the view hierarchy are actively involved views. The processing unit is configured to deliver a respective sub-event to event recognizers for each actively involved view within the view hierarchy. At least one event recognizer for actively involved views in the view hierarchy has a plurality of event definitions, one of which is selected in accordance with the internal state of the electronic device, and the at least one event recognizer processes the respective sub-event prior to processing a next sub-event in the sequence of sub-events in accordance with the selected event definition.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. **1**A-**1**C are block diagrams illustrating electronic devices in accordance with some embodiments.

FIG. **2** is a diagram of an input/output processing stack of an exemplary electronic device in accordance with some embodiments.

FIG. **3**A illustrates an exemplary view hierarchy in accordance with some embodiments.

FIGS. **3**B and **3**C are block diagrams illustrating exemplary event recognizer methods and data structures in accordance with some embodiments.

FIG. **3**D is a block diagram illustrating exemplary components for event handling in accordance with some embodiments.

FIG. **3**E is a block diagram illustrating exemplary classes and instances of gesture recognizers in accordance with some embodiments.

FIG. **3**F is a block diagram illustrating the flow of event information in accordance with some embodiments.

FIGS. **4**A and **4**B are flow charts illustrating exemplary state machines in accordance with some embodiments.

FIG. **4**C illustrates the exemplary state machines of FIGS. **4**A and **4**B to an exemplary set of sub-events in accordance with some embodiments.

FIGS. **5**A-**5**C illustrate exemplary sub-event sequences with exemplary event recognizer state machines in accordance with some embodiments.

FIGS. **6**A and **6**B are event recognition method flow diagrams in accordance with some embodiments.

FIGS. **7**A-**7**S illustrate exemplary user interfaces and user inputs recognized by event recognizers for navigating through concurrently open applications in accordance with some embodiments.

FIGS. **8**A and **8**B are flow diagrams illustrating an event recognition method in accordance with some embodiments.

FIGS. **9**A-**9**C are flow diagrams illustrating an event recognition method in accordance with some embodiments.

FIGS. **10**A-**10**B are flow diagrams illustrating an event recognition method in accordance with some embodiments.

FIG. **11** is a functional block diagram of an electronic device in accordance with some embodiments.

FIG. **12** is a functional block diagram of an electronic device in accordance with some embodiments.

FIG. **13** is a functional block diagram of an electronic device in accordance with some embodiments.

Like reference numerals refer to corresponding parts throughout the drawings.

## DESCRIPTION OF EMBODIMENTS

Electronic devices with small screens (e.g., smart phones and tablets) typically display a single application at a time, even though multiple applications may be running on the device. Many of these devices have touch-sensitive displays configured to receive gesture as touch inputs. With such devices, a user may want to perform operations that are provided by a hidden application (e.g., an application that is running in the background and is not currently displayed on the display of the electronic device, such as an application launcher software application running in the background). Existing methods for performing operations provided by a hidden application typically require first displaying the hidden application and then providing touch inputs to the now displayed application. Therefore, the existing methods require additional steps. Furthermore, the user may not want to see the hidden application, but yet still want to perform an operation provided by the hidden application. In the embodiments described below, improved methods for interacting with a hidden application is achieved by delivering touch inputs to the hidden application, and processing the touch inputs with the hidden application without displaying the hidden application. Thus, these methods streamline the interaction with a hidden application, thereby eliminating the need for extra, separate steps to display the hidden application, while providing the ability to control and interact with the hidden application based on a gesture input.

In addition, in some embodiments, such electronic devices have at least one gesture recognizer with a plurality of gesture definitions. This helps the gesture recognizer work in different distinct operating modes. For example, a device may have a normal operating mode and an accessibility operating mode (e.g., for people with limited vision). In the normal operating mode, a next application gesture is used to move between applications, and the next application gesture is defined as a three-finger left-swipe gesture. In the accessibility operating mode, the three-finger left-swipe gesture is used to perform a different function. Thus, a gesture different from the three-finger left-swipe is needed in the accessibility operating mode to correspond to the next application gesture (e.g., a four-finger left-swipe gesture in the accessibility operating mode). By having multiple gesture definitions associated with the next application gesture, the device can select one of the gesture definitions for the next application gesture, depending on the current operating mode. This provides flexibility in using the gesture recognizer in different operating modes. In some embodiments, a plurality of gesture recognizers with multiple gesture definitions is adjusted depending on the operating mode (e.g., gestures performed with three fingers in the normal operating mode are performed with four fingers in the accessibility operating mode).

Below, FIGS. **1**A-**1**C and **2** provide a description of exemplary devices. FIGS. **3**A-**3**F describe components for event handling and the operation (e.g., flow of event information) of such components. FIGS. **4**A-**4**C and **5**A-**5**C describe operations of event recognizers in more detail. FIGS. **6**A-**6**B are flow diagrams illustrating event recognition methods. FIGS.

7A-7S are exemplary user interfaces illustrating operations using event recognition methods in FIGS. 8A-8B, 9A-9C, and 10. FIGS. 8A-8B are flow diagrams illustrating an event recognition method of processing the event information with a gesture handler of a hidden open application. FIGS. 9A-9C are flow diagrams illustrating an event recognition method of conditionally processing the event information with a gesture recognizer of a hidden open application or a displayed application. FIG. 10 is a flow diagram illustrating an event recognition method of selecting an event definition of a plurality of event definitions for a single event recognizer.

Reference will now be made in detail to embodiments, examples of which are illustrated in the accompanying drawings. In the following detailed description, numerous specific details are set forth in order to provide a thorough understanding of the present invention. However, it will be apparent to one of ordinary skill in the art that the present invention may be practiced without these specific details. In other instances, well-known methods, procedures, components, circuits, and networks have not been described in detail so as not to unnecessarily obscure aspects of the embodiments.

It will also be understood that, although the terms first, second, etc. may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another. For example, a first contact could be termed a second contact, and, similarly, a second contact could be termed a first contact, without departing from the scope of the present invention. The first contact and the second contact are both contacts, but they are not the same contact.

The terminology used in the description of the invention herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the invention. As used in the description of the invention and the appended claims, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will also be understood that the term "and/or" as used herein refers to and encompasses any and all possible combinations of one or more of the associated listed items. It will be further understood that the terms "comprises" and/or "comprising," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

As used herein, the term "if" may be construed to mean "when" or "upon" or "in response to determining" or "in response to detecting," depending on the context. Similarly, the phrase "if it is determined" or "if [a stated condition or event] is detected" may be construed to mean "upon determining" or "in response to determining" or "upon detecting (the stated condition or event)" or "in response to detecting (the stated condition or event)," depending on the context.

As used herein, the term "event" refers to an input detected by one or more sensors of the device. In particular, the term "event" includes a touch on a touch-sensitive surface. An event comprises one or more sub-events. Sub-events typically refer to changes to an event (e.g., a touch-down, touch-move, and lift-off of the touch can be sub-events). Sub-events in the sequence of one or more sub-events can include many forms, including without limitation, key presses, key press holds, key press releases, button presses, button press holds, button press releases, joystick movements, mouse movements, mouse button presses, mouse button releases, pen stylus touches, pen stylus movements, pen stylus releases, oral instructions, detected eye movements, biometric inputs, and detected physiological changes in a user, among others. Since an event may comprise a single sub-event (e.g., a short lateral motion of the device), the term "sub-event" as used herein also refers to an event.

As used herein, the terms "event recognizer" and "gesture recognizer" are used interchangeably to refer to a recognizer that can recognize a gesture or other events (e.g., motion of the device). As used herein, the terms "event handler" and "gesture handler" are used interchangeably to refer to a handler that performs a predefined set of operations (e.g., updating data, updating object(s), and/or updating display) in response to recognition of an event/sub-event or a gesture.

As noted above, in some devices with a touch-sensitive surface as an input device, a first set of touch-based gestures (e.g., two or more of: tap, double tap, horizontal swipe, vertical swipe) are recognized as proper inputs in a particular context (e.g., in a particular mode of a first application), and other, different sets of touch-based gestures are recognized as proper inputs in other contexts (e.g., different applications and/or different modes or contexts within the first application). As a result, the software and logic required for recognizing and responding to touch-based gestures can become complex, and can require revision each time an application is updated or a new application is added to the computing device. Embodiments described herein address these problems by providing a comprehensive framework for handling events and/or gesture inputs.

In the embodiments described below, touch-based gestures are events. Upon recognition of a predefined event, e.g., an event that corresponds to a proper input in the current context of an application, information concerning the event is delivered to the application. Furthermore, each respective event is defined as a sequence of sub-events. In devices that have a multi-touch display device (often herein called "screens") or other multi-touch sensitive surface, and that accept multi-touch-based gestures, the sub-events that define a multi-touched based event may include multi-touch sub-events (requiring two or more fingers to be simultaneously in contact with the device's touch-sensitive surface). For example, in a device having a multi-touch sensitive display, a respective multi-touch sequence of sub-events may begin when a user's finger first touches the screen. Additional sub-events may occur when one or more additional fingers subsequently or concurrently touch the screen, and yet other sub-events may occur when all of the fingers touching the screen move across the screen. The sequence ends when the last of the user's fingers is lifted from the screen.

When using touch-based gestures to control an application running in a device having a touch-sensitive surface, touches have both temporal and spatial aspects. The temporal aspect, called a phase, indicates when a touch has just begun, whether it is moving or stationary, and when it ends—that is, when the finger is lifted from the screen. A spatial aspect of a touch is the set of views or user interface windows in which the touch occurs. The views or windows in which a touch is detected may correspond to programmatic levels within a programmatic or view hierarchy. For example, the lowest level view in which a touch is detected may be called the hit view, and the set of events that are recognized as proper inputs may be determined based, at least in part, on the hit view of the initial touch that begins a touch-based gesture. Alternatively, or additionally, events are recognized as proper inputs based, at least in part, on one or more software programs (i.e., software applications) in the programmatic hierarchy. For example, a five-finger pinch gesture is recognized as a proper input in an application launcher that has a five-finger pinch gesture recognizer, but not in a web browser application that does not have the five-finger pinch gesture recognizer.

FIGS. **1A-1C** are block diagrams illustrating different embodiments of electronic device **102**, in accordance with some embodiments. Electronic device **102** may be any electronic device including, but not limited to, a desktop computer system, a laptop computer system, a mobile phone, a smart phone, a personal digital assistant, or a navigation system. Electronic device **102** may also be a portable electronic device with a touch screen display (e.g., touch-sensitive display **156**, FIG. **1**B) configured to present a user interface, a computer with a touch screen display configured to present a user interface, a computer with a touch sensitive surface and a display configured to present a user interface, or any other form of computing device, including without limitation, consumer electronic devices, mobile telephones, video game systems, electronic music players, tablet PCs, electronic book reading systems, e-books, PDAs, electronic organizers, email devices, laptops or other computers, kiosk computers, vending machines, smart appliances, etc. Electronic device **102** includes user interface **113**.

In some embodiments, electronic device **102** includes a touch-sensitive display **156** (FIG. **1**B). In these embodiments, user interface **113** may include an on-screen keyboard (not depicted) that is used by a user to interact with electronic device **102**. In some embodiments, electronic device **102** also includes one or more input devices **128** (e.g., keyboard, mouse, trackball, microphone, physical button(s), touchpad, etc.). In some embodiments, touch-sensitive display **156** has the ability to detect two or more distinct, concurrent (or partially concurrent) touches, and in these embodiments, display **156** is sometimes herein called a multitouch display or multitouch-sensitive display. In some embodiments, a keyboard of the one or more input devices **128** may be separate and distinct from electronic device **102**. For example, a keyboard may be a wired or wireless keyboard coupled to electronic device **102**.

In some embodiments, electronic device **102** includes display **126** and one or more input devices **128** (e.g., keyboard, mouse, trackball, microphone, physical button(s), touchpad, trackpad, etc.) that are coupled to electronic device **102**. In these embodiments, one or more of input devices **128** may optionally be separate and distinct from electronic device **102**. For example, the one or more input devices may include one or more of: a keyboard, a mouse, a trackpad, a trackball, and an electronic pen, any of which may optionally be separate from the electronic device. Optionally, device **102** may include one or more sensors **116**, such as one or more accelerometers, gyroscopes, GPS systems, speakers, infrared (IR) sensors, biometric sensors, cameras, etc. It is noted that the description above of various exemplary devices as input devices **128** or as sensors **116** is of no significance to the operation of the embodiments described herein, and that any input or sensor device described herein as an input device may equally well be described as a sensor, and vice versa. In some embodiments, signals produced by one or more sensors **116** are used as input sources for detecting events.

In some embodiments, electronic device **102** includes touch-sensitive display **156** (i.e., a display having a touch-sensitive surface) and one or more input devices **128** that are coupled to electronic device **102** (FIG. **1**B). In some embodiments, touch-sensitive display **156** has the ability to detect two or more distinct, concurrent (or partially concurrent) touches, and in these embodiments, display **156** is sometimes herein called a multitouch display or multitouch-sensitive display.

In some embodiments of electronic device **102** discussed herein, input devices **128** are disposed in electronic device **102**. In other embodiments, one or more of input devices **128** is separate and distinct from electronic device **102**. For example, one or more of input devices **128** may be coupled to electronic device **102** by a cable (e.g., USB cable) or wireless connection (e.g., Bluetooth connection).

When using input devices **128**, or when performing a touch-based gesture on touch-sensitive display **156** of electronic device **102**, the user generates a sequence of sub-events that are processed by one or more CPUs **110** of electronic device **102**. In some embodiments, one or more CPUs **110** of the electronic device **102** process the sequence of sub-events to recognize events.

Electronic device **102** typically includes one or more single- or multi-core processing units ("CPU" or "CPUs") **110** as well as one or more network or other communications interfaces **112**. Electronic device **102** includes memory **111** and one or more communication buses **115** for interconnecting these components. Communication buses **115** may include circuitry (sometimes called a chipset) that interconnects and controls communications between system components (not depicted herein). As discussed above, electronic device **102** includes user interfaces **113** including a display (e.g., display **126** or touch-sensitive display **156**). Further, electronic device **102** typically includes input devices **128** (e.g., keyboard, mouse, touch sensitive surfaces, keypads, etc.). In some embodiments, the input devices **128** include an on-screen input device (e.g., a touch-sensitive surface of a display device). Memory **111** may include high-speed random access memory, such as DRAM, SRAM, DDR RAM or other random access solid state memory devices; and may include non-volatile memory, such as one or more magnetic disk storage devices, optical disk storage devices, flash memory devices, or other non-volatile solid state storage devices. Memory **111** may optionally include one or more storage devices remotely located from the CPU(s) **110**. Memory **111**, or alternately the non-volatile memory device(s) within memory **111**, comprise a computer readable storage medium. In some embodiments, memory **111**, or the non-volatile memory device(s) within memory **111**, comprises a non-transitory computer readable storage medium. In some embodiments, memory **111** (of electronic device **102**) or the computer readable storage medium of memory **111** stores the following programs, modules and data structures, or a subset thereof:

- operating system **118**, which includes procedures for handling various basic system services and for performing hardware dependent tasks;
- accessibility module **127** (FIG. **1**C), which is used for modifying behavior of one or more software applications in application software **124** or modifying data from touch-sensitive display **156** or input device(s) **128** to improve accessibility of the one or more software applications in application software **124** or accessibility to content (e.g., a web page) displayed therein (e.g., for people with impaired vision or limited motion capabilities);
- communication module **120**, which is used for connecting electronic device **102** to other devices via one or more respective communication interfaces **112** (wired or wireless) and one or more communication networks, such as the Internet, other wide area networks, local area networks, metropolitan area networks, and so on;
- user interface module **123** (FIG. **1**C), which is used for displaying user interfaces including user interface objects on display **126** or touch-sensitive display **156**;
- control application **132** (FIG. **1**C), which is used for controlling processes (e.g., hit view determination, thread management, and/or event monitoring, etc.); in some

embodiments, control application **132** includes a run-time application; in other embodiments, the run-time application includes control application **132**;

event delivery system **122**, which may be implemented in various alternate embodiments within operating system **118** or in application software **124**; in some embodiments, however, some aspects of event delivery system **122** may be implemented in operating system **118** while other aspects are implemented in application software **124**;

application software **124**, which includes one or more software applications (e.g., applications **133-1**, **133-2**, and **133-3** in FIG. **1**C, each of which can be one of: an email application, a web browser application, a notes application, a text messaging application, etc.); a respective software application typically has, at least during execution, an application state, indicating the state of the respective software application and its components (e.g., gesture recognizers); see application internal state **321** (FIG. **3**D) described below; and

device/global internal state **134** (FIG. **1**C), which includes one or more of: application state, indicating the state of software applications and their components (e.g., gesture recognizers and delegates); display state, indicating what applications, views or other information occupy various regions of touch-sensitive display **156** or display **126**; sensor state, including information obtained from the device's various sensors **116**, input devices **128**, and/or touch-sensitive display **156**; location information concerning the device's location and/or attitude; and other states.

As used in the specification and claims, the term "open application" refers to a software application with retained state information (e.g., as part of device/global internal state **134** and/or application internal state **321** (FIG. **3**D)). An open application is any one of the following types of applications:

an active application, which is currently displayed on display **126** or touch-sensitive display **156** (or a corresponding application view is currently displayed on the display);

a background application (or background process), which is not currently displayed on display **126** or touch-sensitive display **156**, but one or more application processes (e.g., instructions) for the corresponding application are being processed by one or more processors **110** (i.e., running);

a suspended application, which is not currently running, and the application is stored in a volatile memory (e.g., DRAM, SRAM, DDR RAM, or other volatile random access solid state memory device of memory **111**); and

a hibernated application, which is not running, and the application is stored in a non-volatile memory (e.g., one or more magnetic disk storage devices, optical disk storage devices, flash memory devices, or other non-volatile solid state storage devices of memory **111**).

As used herein, the term "closed application" refers to software applications without retained state information (e.g., state information for closed applications is not stored in a memory of the device). Accordingly, closing an application includes stopping and/or removing application processes for the application and removing state information for the application from the memory of the device. Generally, opening a second application while in a first application does not close the first application. When the second application is displayed and the first application ceases to be displayed, the first application, which was an active application when displayed, may become a background application, suspended application, or hibernated application, but the first application remains an open application while its state information is retained by the device.

Each of the above identified elements may be stored in one or more of the previously mentioned memory devices. Each of the above identified module, application or system elements corresponds to a set of instructions for performing functions described herein. The set of instructions can be executed by one or more processors (e.g., one or more CPUs **110**). The above identified modules or programs (i.e., sets of instructions) need not be implemented as separate software programs, procedures or modules, and thus various subsets of these modules may be combined or otherwise rearranged in various embodiments. In some embodiments, memory **111** may store a subset of the modules and data structures identified above. Furthermore, memory **111** may store additional modules and data structures not described above.

FIG. **2** is a diagram of input/output processing stack **200** of an exemplary electronic device or apparatus (e.g., device **102**) according to some embodiments of the invention. Hardware (e.g., electronic circuitry) **212** of the device is at the base level of the input/output processing stack **200**. Hardware **212** can include various hardware interface components, such as the components depicted in FIGS. **1**A and/or **1**B. Hardware **212** can also include one or more of above mentioned sensors **116**. At least some of the other elements (**202-210**) of input/output processing stack **200** are software procedures, or portions of software procedures, that process inputs received from hardware **212** and generate various outputs that are presented through a hardware user interface (e.g., one or more of a display, speakers, device vibration actuator, etc.).

A driver or a set of drivers **210** communicates with hardware **212**. Drivers **210** can receive and process input data received from hardware **212**. Core Operating System ("OS") **208** can communicate with driver(s) **210**. Core OS **208** can process raw input data received from driver(s) **210**. In some embodiments, drivers **210** can be considered to be a part of core OS **208**.

A set of OS application programming interfaces ("OS APIs") **206**, are software procedures that communicate with core OS **208**. In some embodiments, APIs **206** are included in the device's operating system, but at a level above core OS **208**. APIs **206** are designed for use by applications running on the electronic devices or apparatuses discussed herein. User interface (UI) APIs **204** can utilize OS APIs **206**. Application software ("applications") **202** running on the device can utilize UI APIs **204** in order to communicate with the user. UI APIs **204** can, in turn, communicate with lower level elements, ultimately communicating with various user interface hardware, e.g., multitouch display **156**. In some embodiments, application software **202** includes applications in application software **124** (FIG. **1**A).

While each layer input/output processing stack **200** can utilize the layer underneath it, that is not always required. For example, in some embodiments, applications **202** may directly communicate with OS APIs **206**. In general, layers at or above OS API layer **206** may not directly access Core OS **208**, driver(s) **210**, or hardware **212**, as these layers are considered private. Applications in layer **202** and UI API **204** usually direct calls to the OS API **206**, which in turn, accesses the layers Core OS **208**, driver(s) **210**, and hardware **212**.

Stated in another way, one or more hardware elements **212** of electronic device **102**, and software running on the device detect input events (which may correspond to sub-events in a gesture) at one or more of the input device(s) **128** and/or a touch-sensitive display **156** and generate or update various data structures (stored in memory **111** of device **102**) used by

a set of currently active event recognizers to determine whether and when the input events correspond to an event to be delivered to application **124**. Embodiments of event recognition methodologies, apparatus and computer program products are described in more detail below.

FIG. **3**A depicts an exemplary view hierarchy **300**, which in this example is a search program displayed in outermost view **302**. Outermost view **302** generally encompasses the entire user interface a user may directly interact with, and includes subordinate views, e.g.,

- search results panel **304**, which groups search results and can be scrolled vertically;
- search field **306**, which accepts text inputs; and
- a home row **310**, which groups applications for quick access.

In this example, each subordinate view includes lower-level subordinate views. In other examples, the number of view levels in the hierarchy **300** may differ in different branches of the hierarchy, with one or more subordinate views having lower-level subordinate views, and one or more other subordinate views not have any such lower-level subordinate views. Continuing with the example shown in FIG. **3**A, search results panel **304** contains separate subordinate views **305** (subordinate to panel **304**) for each search result. Here, this example shows one search result in a subordinate view called the maps view **305**. Search field **306** includes a subordinate view herein called clear contents icon view **307**, which clears the contents of the search field when a user performs a particular action (e.g., a single touch or tap gesture) on the clear contents icon in view **307**. Home row **310** includes subordinate views **310-1**, **310-2**, **310-3**, and **310-4**, which respectively correspond to a contacts application, an email application, a web browser, and an iPod music interface.

A touch sub-event **301-1** is represented in outermost view **302**. Given the location of touch sub-event **301-1** over both the search results panel **304**, and maps view **305**, the touch sub-event is also represented over those views as **301-2** and **301-3**, respectively. Actively involved views of the touch sub-event include the views search results panel **304**, maps view **305** and outermost view **302**. Additional information regarding sub-event delivery and actively involved views is provided below with reference to FIGS. **3**B and **3**C.

Views (and corresponding programmatic levels) can be nested. In other words, a view can include other views. Consequently, the software element(s) (e.g., event recognizers) associated with a first view can include or be linked to one or more software elements associated with views within the first view. While some views can be associated with applications, others can be associated with high level OS elements, such as graphical user interfaces, window managers, etc. In some embodiments, some views are associated with other OS elements. In some embodiments, the view hierarchy includes views from a plurality of software applications. For example, the view hierarchy may include a view from an application launcher (e.g., a home screen) and a view from a web browser application (e.g., a view including content of a web page).

A programmatic hierarchy includes one or more software elements or software applications in a hierarchy. To simplify subsequent discussion, reference will generally be made only to views and the view hierarchy, but it must be understood that in some embodiments, the method may operate with a programmatic hierarchy with a plurality of programmatic layers, and/or a view hierarchy.

FIGS. **3**B and **3**C depict exemplary methods and structures related to event recognizers. FIG. **3**B depicts methods and data structures for event handling when event handlers are associated with particular views within a hierarchy of views. FIG. **3**C depicts methods and data structures for event handling when event handlers are associated with particular levels within a hierarchy of programmatic levels. Event recognizer global methods **312** and **350** include hit view and hit level determination modules **314** and **352**, respectively, active event recognizer determination modules **316** and **354**, and sub-event delivery modules **318** and **356**.

In some embodiments, electronic device **102** includes one or more of: event recognizer global methods **312** and **350**. In some embodiments, electronic device **102** includes one or more of: hit view determination module **314** and hit level determination module **352**. In some embodiments, electronic device **102** includes one or more of: active event recognizer determination modules **316** and **354**. In some embodiments, electronic device **102** includes one or more of: sub-event delivery modules **318** and **356**. In some embodiments, one or more of these methods and modules are included in fewer or more methods and modules. For example, in some embodiments, electronic device **102** includes a hit view/level determination module which includes the functionality of hit view determination module **314** and hit level determination module **352**. In some embodiments, electronic device **102** includes an active event recognizer determination module which includes the functionality of active event recognizer determination modules **316** and **354**.

Hit view and hit level determination modules, **314** and **352**, respectively, provide software procedures for determining where a sub-event has taken place within one or more views (e.g., the exemplary view hierarchy **300** depicted in FIG. **3**A, which has three main branches) and/or one or more software elements in the programmatic hierarchy that correspond to the sub-event (e.g., one or more of applications **133** in FIG. **1**C).

The hit view determination module **314** of FIG. **3**B, receives information related to a sub-event, e.g., a user touch represented as **301-1** on the outermost view **302**, on a search result (maps view **305**) and the search results panel view **304**. The hit view determination module **314** identifies a hit-view as the lowest view in the hierarchy which should handle the sub-event. In most circumstances, the hit view is the lowest level view in which an initiating sub-event (i.e., the first sub-event in the sequence of sub-events that form an event or potential event) occurs. In some embodiments, once the hit-view is identified, it will receive all sub-events related to the same touch or input source for which the hit view was identified. In some embodiments, one or more other views (e.g., a default or predefined view) receive at least some of the sub-events that the hit view receives.

In some embodiments, the hit level determination module **352** of FIG. **3**C may utilize an analogous process. For example, in some embodiments, the hit level determination module **352** identifies a hit level as the lowest level in the programmatic hierarchy (or a software application in the lowest programmatic level in the programmatic hierarchy) which should handle the sub-event. In some embodiments, once the hit level is identified, it or a software application in the hit level will receive all sub-events related to the same touch or input source for which the hit level was identified. In some embodiments, one or more other levels or software applications (e.g., a default or predefined software application) receive at least some of the sub-events that the hit view receives.

Active event recognizer determination modules **316** and **354** of event recognizer global methods **312** and **350**, respectively, determine which view or views within a view hierarchy and/or a programmatic hierarchy should receive a particular sequence of sub-events. FIG. **3**A depicts an exemplary set of

active views, **302**, **304** and **305**, that receive the sub-event **301**. In the example of FIG. **3**A, the active event recognizer determination module **316** would determine that the outermost view **302**, search results panel **304** and maps view **305** are actively involved views because these views include the physical location of the touch represented by sub-event **301**. It is noted that even if touch sub-event **301** were entirely confined to the area associated with maps view **305**, search results panel **304** and outermost view **302** would still remain in the actively involved views since the search results panel **304** and outermost view **302** are ancestors of maps view **305**.

In some embodiments, active event recognizer determination modules **316** and **354** utilize analogous processes. In the example of FIG. **3**A, the active event recognizer determination module **350** would determine that the map application is actively involved because the views of the map application are displayed and/or the views of the map application include the physical location of the touch represented by sub-event **301**. It is noted that even if touch sub-event **301** were entirely confined to the area associated with the map application, other applications in the programmatic hierarchy may still remain as actively involved applications (or applications in the actively involved programmatic levels).

Sub-event delivery module **318** delivers sub-events to event recognizers for actively involved views. Using the example of FIG. **3**A, a user's touch is represented in different views of the hierarchy by touch marks **301-1**, **301-2**, and **301-3**. In some embodiments, sub-event data representing this user's touch is delivered by the sub-event delivery module **318** to event recognizers at the actively involved views, i.e., top level view **302**, search results panel **304** and maps view **305**. Further, the event recognizers of a view can receive subsequent sub-events of an event that starts within the view (e.g., when an initial sub-event occurs within the view). Stated in another way, a view can receive sub-events associated with user interactions beginning in the view, even if it continues outside of the view.

In some embodiments, sub-event delivery module **356** delivers sub-events to event recognizers for actively involved programmatic levels in a process analogous to that used by sub-event delivery module **318**. For example, sub-event delivery module **356** delivers sub-events to event recognizers for actively involved applications. Using the example of FIG. **3**A, a user's touch **301** is delivered by sub-event delivery module **356** to event recognizers at the actively involved views (e.g., the map application and any other actively involved applications in the programmatic hierarchy). In some embodiments, a default or predefined software application is included in the programmatic hierarchy by default.

In some embodiments, a separate event recognizer structure **320** or **360** is generated and stored in memory of the device for each actively involved event recognizer Event recognizer structures **320** and **360** typically include an event recognizer state **334**, **374**, respectively (discussed in greater detail below when referring to FIGS. **4**A and **4**B), and event recognizer specific code **338**, **378**, respectively, having state machines **340**, **380**, respectively. Event recognizer structure **320** also includes a view hierarchy reference **336**, while event recognizer structure **360** includes a programmatic hierarchy reference **376**. Each instance of a particular event recognizer references exactly one view or programmatic level. View hierarchy reference **336** or programmatic hierarchy reference **376** (for a particular event recognizer) is used to establish which view or programmatic level is logically coupled to the respective event recognizer.

View metadata **341** and level metadata **381** may include data regarding a view or level, respectively. View or level metadata may include at least the following properties that may influence sub-event delivery to event recognizers:

- A stop property **342**, **382**, which, when set for a view or programmatic level prevents sub-event delivery to event recognizers associated with the view or programmatic level as well as its ancestors in the view or programmatic hierarchy.
- A skip property **343**, **383**, which, when set for a view or programmatic level prevents sub-event delivery to event recognizers associated with that view or programmatic level, but permits sub-event delivery to its ancestors in the view or programmatic hierarchy.
- A NoHit skip property **344**, **384**, which, when set for a view, prevents delivery of sub-events to event recognizers associated with the view unless the view is the hit view. As discussed above, the hit view determination module **314** identifies a hit-view (or hit level in the case of hit level determination module **352**) as the lowest view in the hierarchy which should handle the sub-event.

Event recognizer structures **320** and **360** may include metadata **322**, **362**, respectively. In some embodiments, the metadata **322**, **362** includes configurable properties, flags, and lists that indicate how the event delivery system should perform sub-event delivery to actively involved event recognizers. In some embodiments, metadata **322**, **362** may include configurable properties, flags, and lists that indicate how event recognizers may interact with one another. In some embodiments, metadata **322**, **362** may include configurable properties, flags, and lists that indicate whether sub-events are delivered to varying levels in the view or programmatic hierarchy. In some embodiments, the combination of event recognizer metadata **322**, **362** and view or level metadata (**341**, **381**, respectively) are both be used to configure the event delivery system to: a) perform sub-event delivery to actively involved event recognizers, b) indicate how event recognizers may interact with one another, and c) indicate whether and when sub-events are delivered to various levels in the view or programmatic hierarchy.

It is noted that, in some embodiments, a respective event recognizer sends an event recognition action **333**, **373** to its respective target **335**, **375**, as specified by fields of the event recognizer's structure **320**, **360**. Sending an action to a target is distinct from sending (and deferred sending) sub-events to a respective hit view or level.

The metadata properties stored in a respective event recognizer structure **320**, **360** of a corresponding event recognizer includes one or more of:

- An exclusivity flag **324**, **364**, which, when set for an event recognizer, indicates that upon recognition of an event by the event recognizer, the event delivery system should stop delivering sub-events to any other event recognizers of the actively involved views or programmatic levels (with the exception of any other event recognizers listed in an exception list **326**, **366**). When receipt of a sub-event causes a particular event recognizer to enter the exclusive state, as indicated by its corresponding exclusivity flag **324** or **364**, then subsequent sub-events are delivered only to the event recognizer in the exclusive state (as well as any other event recognizers listed in an exception list **326**, **366**).
- Some event recognizer structures **320**, **360**, may include an exclusivity exception list **326**, **366**. When included in the event recognizer structure **320**, **360** for a respective event recognizer, this list **326**, **366** indicates the set of event recognizers, if any, that are to continue receiving sub-events even after the respective event recognizer has entered the exclusive state. For example, if the event

recognizer for a single tap event enters the exclusive state, and the currently involved views include an event recognizer for a double tap event, then the list **320**, **360** would list the double tap event recognizer so that a double tap event can be recognized even after a single tap event has been detected. Accordingly, the exclusivity exception list **326**, **366** permits event recognizers to recognize different events that share common sequences of sub-events, e.g., a single tap event recognition does not preclude subsequent recognition of a double or triple tap event by other event recognizers.

Some event recognizer structures **320**, **360**, may include a wait-for list **327**, **367**. When included in the event recognizer structure **320**, **360** for a respective event recognizer, this list **327**, **367** indicates the set of event recognizers, if any, that must enter the event impossible or event canceled state before the respective event recognizer can recognize a respective event. In effect, the listed event recognizers have higher priority for recognizing an event than the event recognizer with the wait-for list **327**, **367**.

A delay touch began flag **328**, **368**, which, when set for an event recognizer, causes the event recognizer to delay sending sub-events (including a touch begin or finger down sub-event, and subsequent events) to the event recognizer's respective hit view or level until after it has been determined that the sequence of sub-events does not correspond to this event recognizer's event type. This flag can be used to prevent the hit view or level from ever seeing any of the sub-events in the case where the gesture is recognized. When the event recognizer fails to recognize an event, the touch began sub-event (and subsequent touch end sub-event) can be delivered to the hit view or level. In one example, delivering such sub-events to the hit view or level causes the user interface to briefly highlight an object, without invoking the action associated with that object.

A delay touch end flag **330**, **370**, which, when set for an event recognizer, causes the event recognizer to delay sending a sub-event (e.g., a touch end sub-event) to the event recognizer's respective hit view or level until it has been determined that the sequence of sub-events does not correspond to this event recognizer's event type. This can be used to prevent the hit view or level from acting upon a touch end sub-event, in case the gesture is later recognized. As long as the touch end sub-event is not sent, a touch canceled can be sent to the hit view or level. If an event is recognized, the corresponding action by an application is preformed, and the touch end sub-event is delivered to the hit view or level.

A touch cancellation flag **332**, **372**, which, when set for an event recognizer, causes the event recognizer to send touch or input cancellation to the event recognizer's respective hit view or hit level when it has been determined that the sequence of sub-events does not correspond to this event recognizer's event type. The touch or input cancellation sent to the hit view or level indicates that a prior sub-event (e.g., a touch began sub-event) has been cancelled. The touch or input cancellation may cause the input source handler's state (see FIG. **4**B) to enter the input sequence cancelled state **460** (discussed below).

In some embodiments, the exception list **326**, **366** can also be used by non-exclusive event recognizers. In particular, when a non-exclusive event recognizer recognizes an event, subsequent sub-events are not delivered to the exclusive event recognizers associated with the currently active views, except for those exclusive event recognizers listed in the exception list **326**, **366** of the event recognizer that recognized the event.

In some embodiments, event recognizers may be configured to utilize the touch cancellation flag in conjunction with the delay touch end flag to prevent unwanted sub-events from being delivered to the hit view. For example, the definition of a single tap gesture and the first half of a double tap gesture are identical. Once a single tap event recognizer successfully recognizes a single tap, an undesired action could take place. If the delay touch end flag is set, the single tap event recognizer is prevented from sending sub-events to the hit view until a single tap event is recognized. In addition, the wait-for list of the single tap event recognizer may identify the double-tap event recognizer, thereby preventing the single tap event recognizer from recognizing a single tap until the double-tap event recognizer has entered the event impossible state. The use of the wait-for list avoids the execution of actions associated with a single tap when a double tap gesture is performed. Instead, only actions associated with a double tap will be executed, in response to recognition of the double tap event.

Turning in particular to forms of user touches on touch-sensitive surfaces, as noted above, touches and user gestures may include an act that need not be instantaneous, e.g., a touch can include an act of moving or holding a finger against a display for a period of time. A touch data structure, however, defines the state of a touch (or, more generally, the state of any input source) at a particular time. Therefore, the values stored in a touch data structure may change over the course of a single touch, enabling the state of the single touch at different points in time to be conveyed to an application.

Each touch data structure can comprise various fields. In some embodiments, touch data structures may include data corresponding to at least the touch-specific fields **339** in FIG. **3**B or input source specific fields **379** in FIG. **3**C.

For example, a "first touch for view" field **345** in FIG. **3**B (**385** for "first touch for level" in FIG. **3**C) can indicate whether the touch data structure defines the first touch for the particular view (since the software element implementing the view was instantiated). A "time stamp" field **346**, **386** can indicate the particular time to which the touch data structure relates.

Optionally, an "info" field **347**, **387** can be used to indicate if a touch is a rudimentary gesture. For example, the "info" field **347**, **387** can indicate whether the touch is a swipe and, if so, in which direction the swipe is oriented. A swipe is a quick drag of one or more fingers in a straight direction. API implementations (discussed below) can determine if a touch is a swipe and pass that information to the application through the "info" field **347**, **387**, thus alleviating the application of some data processing that would have been necessary if the touch were a swipe.

Optionally, a "tap count" field **348** in FIG. **3**B ("event count" field **388** in FIG. **3**C) can indicate how many taps have been sequentially performed at the position of the initial touch. A tap can be defined as a quick pressing and lifting of a finger against a touch-sensitive panel at a particular position. Multiple sequential taps can occur if the finger is again pressed and released in quick succession at the same position of the panel. An event delivery system **122** can count taps and relay this information to an application through the "tap count" field **348**. Multiple taps at the same location are sometimes considered to be a useful and easy to remember command for touch enabled interfaces. Thus, by counting taps, the event delivery system **122** can again alleviate some data processing from the application.

A "phase" field **349**, **389** can indicate a particular phase the touch-based gesture is currently in. The phase field **349**, **389** can have various values, such as "touch phase began" which can indicate that the touch data structure defines a new touch that has not been referenced by previous touch data structures. A "touch phase moved" value can indicate that the touch being defined has moved from a prior position. A "touch phase stationary" value can indicate that the touch has stayed in the same position. A "touch phase ended" value can indicate that the touch has ended (e.g., the user has lifted his/her finger from the surface of a multi touch display). A "touch phase cancelled" value can indicate that the touch has been cancelled by the device. A cancelled touch can be a touch that is not necessarily ended by a user, but which the device has determined to ignore. For example, the device can determine that the touch is being generated inadvertently (i.e., as a result of placing a portable multi touch enabled device in one's pocket) and ignore the touch for that reason. Each value of the "phase field" **349**, **389** can be an integer number.

Thus, each touch data structure can define what is happening with a respective touch (or other input source) at a particular time (e.g., whether the touch is stationary, being moved, etc.) as well as other information associated with the touch (such as position). Accordingly, each touch data structure can define the state of a particular touch at a particular moment in time. One or more touch data structures referencing the same time can be added in a touch event data structure that can define the states of all touches a particular view is receiving at a moment in time (as noted above, some touch data structures may also reference touches that have ended and are no longer being received). Multiple touch event data structures can be sent to the software implementing a view as time passes, in order to provide the software with continuous information describing the touches that are happening in the view.

FIG. **3**D is a block diagram illustrating exemplary components for event handling (e.g., event handling components **390**) in accordance with some embodiments. In some embodiments, memory **111** (FIG. **1**A) includes event recognizer global methods **312** and one or more applications (e.g., **133-1** through **133-3**).

In some embodiments, event recognizer global methods **312** include event monitor **311**, hit view determination module **314**, active event recognizer determination module **316**, and event dispatcher module **315**. In some embodiments, event recognizer global methods **312** are located within event delivery system **122** (FIG. **1**A). In some embodiments, event recognizer global methods **312** are implemented in operating system **118** (FIG. **1**A). Alternatively, event recognizer global methods **312** are implemented in a respective application **133-1**. In yet other embodiments, event recognizer global methods **312** are implemented as a stand-alone module, or a part of another module stored in memory **111** (e.g., a contact/motion module (not depicted)).

Event monitor **311** receives event information from one or more sensors **116**, touch-sensitive display **156**, and/or one or more input devices **128**. Event information includes information about an event (e.g., a user touch on touch-sensitive display **156**, as part of a multi-touch gesture or a motion of device **102**) and/or a sub-event (e.g., a movement of a touch across touch-sensitive display **156**). For example, event information for a touch event includes one or more of: a location and time stamp of a touch. Similarly, event information for a swipe event includes two or more of: a location, time stamp, direction, and speed of a swipe. Sensors **116**, touch-sensitive display **156**, and input devices **128** transmit information event and sub-event information to event monitor **311** either directly or through a peripherals interface, which retrieves and stores event information. Sensors **116** include one or more of: proximity sensor, accelerometer(s), gyroscopes, microphone, and video camera. In some embodiments, sensors **116** also include input devices **128** and/or touch-sensitive display **156**.

In some embodiments, event monitor **311** sends requests to sensors **116** and/or the peripherals interface at predetermined intervals. In response, sensors **116** and/or the peripherals interface transmit event information. In other embodiments, sensors **116** and the peripheral interface transmit event information only when there is a significant event (e.g., receiving an input beyond a predetermined noise threshold and/or for more than a predetermined duration).

Event monitor **311** receives event information and relays the event information to event dispatcher module **315**. In some embodiments, event monitor **311** determines one or more respective applications (e.g., **133-1**) to which to deliver the event information. In some embodiments, event monitor **311** also determines one or more respective application views **317** of the one or more respective applications to which to deliver the event information.

In some embodiments, event recognizer global methods **312** also include a hit view determination module **314** and/or an active event recognizer determination module **316**.

Hit view determination module **314**, if present, provides software procedures for determining where an event or a sub-event has taken place within one or more views, when touch-sensitive display **156** displays more than one view. Views are made up of controls and other elements that a user can see on the display.

Another aspect of the user interface associated with a respective application (e.g., **133-1**) is a set of views **317**, sometimes herein called application views or user interface windows, in which information is displayed and touch-based gestures occur. The application views (of a respective application) in which a touch is detected may correspond to a particular view within a view hierarchy of the application. For example, the lowest level view in which a touch is detected may be called the hit view, and the set of events that are recognized as proper inputs may be determined based, at least in part, on the hit view of the initial touch that begins a touch-based gesture.

Hit view determination module **314** receives information related to events and/or sub-events. When an application has multiple views organized in a hierarchy, hit view determination module **314** identifies a hit view as the lowest view in the hierarchy which should handle the event or sub-event. In most circumstances, the hit view is the lowest level view in which an initiating event or sub-event occurs (i.e., the first event or sub-event in the sequence of events and/or sub-events that form a gesture). Once the hit view is identified by the hit view determination module, the hit view typically receives all events and/or sub-events related to the same touch or input source for which it was identified as the hit view. However, the hit view is not always a sole view that receives all events and/or sub-events related to the same touch or input source for which it was identified as the hit view. Stated differently, in some embodiments, another application (e.g., **133-2**) or another view of the same application also receives at least a subset of the events and/or sub-events related to the same touch or input source regardless of whether a hit view has been determined for the touch or input source.

Active event recognizer determination module **316** determines which view or views within a view hierarchy should receive a particular sequence of events and/or sub-events. In some application contexts, active event recognizer determi-

nation module **316** determines that only the hit view should receive a particular sequence of events and/or sub-events. In other application contexts, active event recognizer determination module **316** determines that all views that include the physical location of an event or sub-event are actively involved views, and therefore determines that all actively involved views should receive a particular sequence of events and/or sub-events. In other application contexts, even if touch events and/or sub-events are entirely confined to the area associated with one particular view, views higher in the hierarchy still remain as actively involved views and thus the views higher in the hierarchy should receive a particular sequence of events and/or sub-events. Additionally, or alternatively, active event recognizer determination module **316** determines which application(s) in a programmatic hierarchy should receive a particular sequence of events and/or sub-events. Thus, in some embodiments, active event recognizer determination module **316** determines that only a respective application in the programmatic hierarchy should receive a particular sequence of events and/or sub-events. In some embodiments, active event recognizer determination module **316** determines that a plurality of applications in the programmatic hierarchy should receive a particular sequence of events and/or sub-events.

Event dispatcher module **315** dispatches the event information to an event recognizer (also called herein "gesture recognizer") (e.g., event recognizer **325-1**). In embodiments including active event recognizer determination module **316**, event dispatcher module **315** delivers the event information to an event recognizer determined by active event recognizer determination module **316**. In some embodiments, event dispatcher module **315** stores in an event queue the event information, which is retrieved by a respective event recognizer **325** (or event receiver **3031** in a respective event recognizer **325**).

In some embodiments, a respective application (e.g., **133-1**) includes application internal state **321**, which indicates the current application view(s) displayed on touch-sensitive display **156** when the application is active or executing. In some embodiments, device/global internal state **134** (FIG. **1**C) is used by event recognizer global methods **312** to determine which application(s) is(are) currently active, and application internal state **321** is used by event recognizer global methods **312** to determine application views **317** to which to deliver event information.

In some embodiments, application internal state **321** includes additional information, such as one or more of: resume information to be used when application **133-1** resumes execution, user interface state information that indicates information being displayed or that is ready for display by application **133-1**, a state queue for enabling the user to go back to a prior state or view of application **133-1**, and a redo/undo queue of previous actions taken by the user. In some embodiments, application internal state **321** further includes contextual information/text and metadata **323**.

In some embodiments, application **133-1** includes one or more application views **317**, each of which has corresponding instructions for handling touch events that occur within a respective view of the application's user interface (e.g., a corresponding event handler **319**). At least one application view **317** of the application **133-1** includes one or more event recognizers **325**. Typically, a respective application view **317** includes a plurality of event recognizers **325**. In other embodiments, one or more of event recognizers **325** are part of a separate module, such as a user interface kit (not shown) or a higher level object from which application **133-1** inherits methods and other properties. In some embodiments, a respective application view **317** also includes one or more of: data updater, object updater, GUI updater, and/or event data received.

A respective application (e.g., **133-1**) also includes one or more event handlers **319**. Typically, a respective application (e.g., **133-1**) includes a plurality of event handlers **319**.

A respective event recognizer **325-1** receives event information from event dispatcher module **315** (directly or indirectly through application **133-1**), and identifies an event from the event information. Event recognizer **325-1** includes event receiver **3031** and event comparator **3033**.

The event information includes information about an event (e.g., a touch) or a sub-event (e.g., a touch movement). Depending on the event or sub-event, the event information also includes additional information, such as location of the event or sub-event. When the event or sub-event concerns motion of a touch, the event information may also include speed and direction of the sub-event. In some embodiments, events include rotation of the device from one orientation to another (e.g., from a portrait orientation to a landscape orientation, or vice versa), and the event information includes corresponding information about the current orientation (also called device attitude) of the device.

Event comparator **3033** compares the event information to one or more predefined gesture definitions (also called herein "event definitions") and, based on the comparison, determines an event or sub-event, or determines or updates the state of an event or sub-event. In some embodiments, event comparator **3033** includes one or more gesture definitions **3035** (as described above, also called herein "event definitions"). Gesture definitions **3035** contain definitions of gestures (e.g., predefined sequences of events and/or sub-events), for example, gesture **1** (**3037-1**), gesture **2** (**3037-2**), and others. In some embodiments, sub-events in gesture definitions **3035** include, for example, touch begin, touch end, touch movement, touch cancellation, and multiple touching. In one example, the definition for gesture **1** (**3037-1**) is a double tap on a displayed object. The double tap, for example, comprises a first touch (touch begin) on the displayed object for a predetermined phase of the gesture, a first lift-off (touch end) for a next predetermined phase of the gesture, a second touch (touch begin) on the displayed object for a subsequent predetermined phase of the gesture, and a second lift-off (touch end) for a final predetermined phase of the gesture. In another example, the definition for gesture **2** (**3037-2**) includes a dragging on a displayed object. The dragging, for example, comprises a touch (or contact) on the displayed object, a movement of the touch across touch-sensitive display **156**, and lift-off of the touch (touch end).

In some embodiments, event recognizer **325-1** also includes information for event delivery **3039**. Information for event delivery **3039** includes references to corresponding event handlers **319**. Optionally, information for event delivery **3039** includes action-target pair(s). In some embodiments, in response to recognizing a gesture (or a part of a gesture), event information (e.g., action message(s)) is sent to one or more targets identified by the action-target pair(s). In other embodiments, in response to recognizing a gesture (or a part of a gesture), the action-target pair(s) are activated.

In some embodiments, gesture definitions **3035** include a definition of a gesture for a respective user-interface object. In some embodiments, event comparator **3033** performs a hit test to determine which user-interface object is associated with a sub-event. For example, in an application view in which three user-interface objects are displayed on touch-sensitive display **156**, when a touch is detected on touch-sensitive display **156**, event comparator **3033** performs a hit

test to determine which of the three user-interface objects, if any, is associated with the touch (event). If each displayed object is associated with a respective event handler **319**, event comparator **3033** uses the result of the hit test to determine which event handler **319** should be activated. For example, event comparator **3033** selects an event handler **319** associated with the event and the object triggering the hit test.

In some embodiments, a respective gesture definition **3037** for a respective gesture also includes delayed actions that delay delivery of the event information until after it has been determined whether the sequence of events and/or sub-events does or does not correspond to the event recognizer's event type.

When a respective event recognizer **325-1** determines that the series of events and/or sub-events do not match any of the events in gesture definitions **3035**, the respective event recognizer **325-1** enters an event failed state, after which the respective event recognizer **325-1** disregards subsequent events and/or sub-events of the touch-based gesture. In this situation, other event recognizers, if any, that remain active for the hit view continue to track and process events and/or sub-events of an ongoing touch-based gesture.

In some embodiments, when no event recognizer for the hit view remains, the event information is sent to one or more event recognizers in a higher view in the view hierarchy. Alternatively, when no event recognizer for the hit view remains, the event information is disregarded. In some embodiments, when no event recognizer for views in the view hierarchy remains, the event information is sent to one or more event recognizers in a higher programmatic level in the programmatic hierarchy. Alternatively, when no event recognizer for views in the view hierarchy remains, the event information is disregarded.

In some embodiments, a respective event recognizer **325-1** includes event recognizer state **334**. Event recognizer state **334** includes a state of the respective event recognizer **325-1**. Examples of event recognizer states are described in more detail below with reference to FIGS. **4**A-**4**B and **5**A-**5**C.

In some embodiments, event recognizer state **334** includes recognizer metadata and properties **3043**. In some embodiments, recognizer metadata and properties **3043** include one or more of the following: A) configurable properties, flags, and/or lists that indicate how the event delivery system should perform event and/or sub-event delivery to actively involved event recognizers; B) configurable properties, flags, and/or lists that indicate how event recognizers interact with one another; C) configurable properties, flags, and/or lists that indicate how event recognizers receive event information; D) configurable properties, flags, and/or lists that indicate how event recognizers may recognize a gesture; E) configurable properties, flags, and/or lists that indicate whether events and/or sub-events are delivered to varying levels in the view hierarchy; and F) references to corresponding event handlers **319**.

In some embodiments, event recognizer state **334** includes event/touch metadata **3045**. Event/touch metadata **3045** includes event/touch information about a respective event/touch that has been detected and corresponds to a respective gesture definition **3037** of gesture definitions **3035**. The event/touch information includes one or more of: a location, time stamp, speed, direction, distance, scale (or change in scale), and angle (or change in angle) of the respective event/touch.

In some embodiments, a respective event recognizer **325** activates event handler **319** associated with the respective event recognizer **325** when one or more particular events and/or sub-events of a gesture are recognized. In some embodiments, respective event recognizer **325** delivers event information associated with the event to event handler **319**.

Event handler **319**, when activated, performs one or more of: creating and/or updating data, creating and updating objects, and preparing display information and sending it for display on display **126** or touch-sensitive display **156**.

In some embodiments, a respective application view **317-2** includes view metadata **341**. As described above with respect to FIG. **3**B, view metadata **341** includes data regarding a view. Optionally, view metadata **341** includes one or more of: stop property **342**, skip property **343**, NoHit skip property **344**, and other view metadata **329**.

In some embodiments, a first actively involved view within the view hierarchy may be configured to prevent delivery of a respective sub-event to event recognizers associated with that first actively involved view. This behavior can implement the skip property **343**. When the skip property is set for an application view, delivery of the respective sub-event is still performed for event recognizers associated with other actively involved views in the view hierarchy.

Alternately, a first actively involved view within the view hierarchy may be configured to prevent delivery of a respective sub-event to event recognizers associated with that first actively involved view unless the first actively involved view is the hit view. This behavior can implement the conditional NoHit skip property **344**.

In some embodiments, a second actively involved view within the view hierarchy is configured to prevent delivery of the respective sub-event to event recognizers associated with the second actively involved view and to event recognizers associated with ancestors of the second actively involved view. This behavior can implement the stop property **342**.

FIG. **3**E is a block diagram illustrating exemplary classes and instances of gesture recognizers (e.g., event handling components **390**) in accordance with some embodiments.

A software application (e.g., application **133-1**) has one or more event recognizers **3040**. In some embodiments, a respective event recognizer (e.g., **3040-2**) is an event recognizer class. The respective event recognizer (e.g., **3040-2**) includes event recognizer specific code **338** (e.g., a set of instructions defining the operation of event recognizers) and state machine **340**.

In some embodiments, application state **321** of a software application (e.g., application **133-1**) includes instances of event recognizers. Each instance of an event recognizer is an object having a state (e.g., event recognizer state **334**). "Execution" of a respective event recognizer instance is implemented by executing corresponding event recognizer specific code (e.g., **338**) and updating or maintaining the state **334** of the event recognizer instance **3047**. The state **334** of event recognizer instance **3047** includes the state **3038** of the event recognizer instance's state machine **340**.

In some embodiments, application state **321** includes a plurality of event recognizer instances **3047**. A respective event recognizer instance **3047** typically corresponds to an event recognizer that has been bound (also called "attached") to a view of the application. In some embodiments, one or more event recognizer instances **3047** are bound to a respective application in a programmatic hierarchy without reference to any particular view of the respective application. In some embodiments, application state **321** includes a plurality of instances (e.g., **3047-1** to **3047**-L) of a respective event recognizer (e.g., **3040-2**). In some embodiments, application state **321** includes instances **3047** of a plurality of event recognizers (e.g., **3040-1** to **3040**-R).

In some embodiments, a respective instance **3047-2** of a gesture recognizer **3040** includes event recognizer state **334**.

As discussed above, in some embodiments, event recognizer state **334** includes recognizer metadata and properties **3043** and event/touch metadata **3045**. In some embodiments, event recognizer state **334** also includes view hierarchy reference(s) **336**, indicating to which view the respective instance **3047-2** of the gesture recognizer **3040-2** is attached.

In some embodiments, recognizer metadata and properties **3043** include the following, or a subset or superset thereof:

exclusivity flag **324**;
exclusivity exception list **326**;
wait-for list **327**;
delay touch began flag **328**;
delay touch end flag **330**; and
touch cancellation flag **332**.

In some embodiments, one or more event recognizers may be adapted to delay delivering one or more sub-events of the sequence of sub-events until after the event recognizer recognizes the event. This behavior reflects a delayed event. For example, consider a single tap gesture in a view for which multiple tap gestures are possible. In that case, a tap event becomes a "tap+delay" recognizer. In essence, when an event recognizer implements this behavior, the event recognizer will delay event recognition until it is certain that the sequence of sub-events does in fact correspond to its event definition. This behavior may be appropriate when a recipient view is incapable of appropriately responding to cancelled events. In some embodiments, an event recognizer will delay updating its event recognition status to its respective actively involved view until the event recognizer is certain that the sequence of sub-events does not correspond to its event definition. Delay touch began flag **328**, delay touch end flag **330**, and touch cancellation flag **332** are provided to tailor sub-event delivery techniques, as well as event recognizer and view status information updates to specific needs.

In some embodiments, recognizer metadata and properties **3043** include the following, or a subset or superset thereof:

state machine state/phase **3038**, which indicates the state of a state machine (e.g., **340**) for the respective event recognizer instance (e.g., **3047-2**); state machine state/phase **3038** can have various state values, such as "event possible", "event recognized", "event failed", and others, as described below; alternatively or additionally, state machine state/phase **3038** can have various phase values, such as "touch phase began" which can indicate that the touch data structure defines a new touch that has not been referenced by previous touch data structures; a "touch phase moved" value can indicate that the touch being defined has moved from a prior position; a "touch phase stationary" value can indicate that the touch has stayed in the same position; a "touch phase ended" value can indicate that the touch has ended (e.g., the user has lifted his/her finger from the surface of a multi touch display); a "touch phase cancelled" value can indicate that the touch has been cancelled by the device; a cancelled touch can be a touch that is not necessarily ended by a user, but which the device has determined to ignore; for example, the device can determine that the touch is being generated inadvertently (i.e., as a result of placing a portable multi touch enabled device in one's pocket) and ignore the touch for that reason; each value of state machine state/phase **3038** can be an integer number (called herein "gesture recognizer state value");

action-target pair(s) **3051**, where each pair identifies a target to which the respective event recognizer instance sends the identified action message in response to recognizing an event or touch as a gesture or a part of a gesture;

delegate **3053**, which is a reference to a corresponding delegate when a delegate is assigned to the respective event recognizer instance; when a delegate is not assigned to the respective event recognizer instance, delegate **346** contains a null value; and

enabled property **3055**, indicating whether the respective event recognizer instance is enabled; in some embodiments, when the respective event recognizer instance is not enabled (e.g., disabled), the respective event recognizer instance does not process events or touches.

In some embodiments, exception list **326** can also be used by non-exclusive event recognizers. In particular, when a non-exclusive event recognizer recognizes an event or sub-event, subsequent events and/or sub-events are not delivered to the exclusive event recognizers associated with the currently active views, except for those exclusive event recognizers listed in exception list **326** of the event recognizer that recognized the event or sub-event.

In some embodiments, event recognizers may be configured to utilize the touch cancellation flag **332** in conjunction with the delay touch end flag **330** to prevent unwanted events and/or sub-events from being delivered to the hit view. For example, the definition of a single tap gesture and the first half of a double tap gesture are identical. Once a single tap event recognizer successfully recognizes a single tap, an undesired action could take place. If the delay touch end flag is set, the single tap event recognizer is prevented from sending sub-events to the hit view until a single tap event is recognized. In addition, the wait-for list of the single tap event recognizer may identify the double-tap event recognizer, thereby preventing the single tap event recognizer from recognizing a single tap until the double-tap event recognizer has entered the event impossible state. The use of the wait-for list avoids the execution of actions associated with a single tap when a double tap gesture is performed. Instead, only actions associated with a double tap will be executed, in response to recognition of the double tap event.

Turning in particular to forms of user touches on touch-sensitive surfaces, as noted above, touches and user gestures may include an act that need not be instantaneous, e.g., a touch can include an act of moving or holding a finger against a display for a period of time. A touch data structure, however, defines the state of a touch (or, more generally, the state of any input source) at a particular time. Therefore, the values stored in a touch data structure may change over the course of a single touch, enabling the state of the single touch at different points in time to be conveyed to an application.

Each touch data structure can comprise various entries. In some embodiments, touch data structures may include data corresponding to at least the touch-specific entries in event/touch metadata **3045** such as the following, or a subset or superset thereof:

"first touch for view" entry **345**;

"per touch info" entry **3051**, including "time stamp" information, which indicates the particular time to which the touch data structure relates (e.g., the time of touch); optionally, "per touch info" entry **3051** includes other information, such as a location of a corresponding touch; and

optional "tap count" entry **348**.

Thus, each touch data structure can define what is happening with a respective touch (or other input source) at a particular time (e.g., whether the touch is stationary, being moved, etc.) as well as other information associated with the touch (such as position). Accordingly, each touch data structure can define the state of a particular touch at a particular moment in time. One or more touch data structures referenc-

ing the same time can be added in a touch event data structure that can define the states of all touches a particular view is receiving at a moment in time (as noted above, some touch data structures may also reference touches that have ended and are no longer being received). Multiple touch event data structures can be sent to the software implementing a view as time passes, in order to provide the software with continuous information describing the touches that are happening in the view.

The ability to handle complex touch-based gestures, optionally including multi-touch gestures, can add complexity to the various software applications. In some cases, such additional complexity can be necessary to implement advanced and desirable interface features. For example, a game may require the ability to handle multiple simultaneous touches that occur in different views, as games often require the pressing of multiple buttons at the same time, or combining accelerometer data with touches on a touch-sensitive surface. However, some simpler applications and/or views need not require advanced interface features. For example, a simple soft button (i.e., a button that is displayed on a touch-sensitive display) may operate satisfactorily with single touches, rather than multi-touch functionality. In these cases, the underlying OS may send unnecessary or excessive touch data (e.g., multi-touch data) to a software component associated with a view that is intended to be operable by single touches only (e.g., a single touch or tap on a soft button). Because the software component may need to process this data, it may need to feature all the complexity of a software application that handles multiple touches, even though it is associated with a view for which only single touches are relevant. This can increase the cost of development of software for the device, because software components that have been traditionally easy to program in a mouse interface environment (i.e., various buttons, etc.) may be much more complex in a multi-touch environment.

In order to reduce the complexity in recognizing complex touch-based gestures, delegates can be used to control the behavior of event recognizers in accordance with some embodiments. As described below, delegates can determine, for example, whether a corresponding event recognizer (or gesture recognizer) can receive the event (e.g., touch) information; whether the corresponding event recognizer (or gesture recognizer) can transition from an initial state (e.g., event possible state) of state machine to another state; and/or whether the corresponding event recognizer (or gesture recognizer) can simultaneously recognize the event (e.g., touch) as a corresponding gesture without blocking other event recognizer(s) (or gesture recognizer(s)) from recognizing the event or getting blocked by other event recognizer(s) (or gesture recognizer(s)) recognizing the event.

It shall be understood, however, that the foregoing discussion regarding the complexity of evaluating and processing user touches on touch-sensitive surfaces also applies to all forms of user inputs to operate electronic device **102** with input devices **128**, not all of which are initiated on touch screens, e.g., coordinating mouse movement and mouse button presses with or without single or multiple keyboard presses or holds, device rotations or other movements, user movements such as taps, drags, scrolls, etc., on touch-pads, pen stylus inputs, oral instructions, detected eye movements, biometric inputs, detected physiological change in a user, and/or any combination thereof, which may be utilized as inputs corresponding to events and/or sub-events which define an event to be recognized.

Turning to the flow of event information, FIG. **3**F is a block diagram illustrating the flow of event information in accordance with some embodiments. Event dispatcher module **315** (e.g., in operating system **118** or application software **124**) receives event information, and sends the event information to one or more applications (e.g., **133-1** and **133-2**). In some embodiments, application **133-1** includes a plurality of views (e.g., **508**, **510**, and **512** corresponding to views **317**, FIG. **3**D) in view hierarchy **506** and a plurality of gesture recognizers (**516-1** through **516-3**) in the plurality of views. Application **133-1** also includes one or more gesture handlers **550**, which correspond to the target values in target-action pairs (e.g., **552-1** and **552-2**). In some embodiments, event dispatcher module **315** receives hit view information from hit view determination module **314** and sends event information to the hit view (e.g., **512**) or event recognizer(s) attached to the hit view (e.g., **516-1** and **516-2**). Additionally or alternatively, event dispatcher module **315** receives hit level information from hit level determination module **352** and sends event information to applications in the hit level (e.g., **133-1** and **133-2**) or one or more event recognizers (e.g., **516-4**) in the hit level applications. In some embodiments, one of the applications receiving the event information is a default application (e.g., **133-2** may be a default application). In some embodiments, only a subset of gesture recognizers in each receiving application is allowed to (or configured to) receive the event information. For example, gesture recognizer **516-3** in application **133-1** does not receive the event information. The gesture recognizers that receive the event information are called herein receiving gesture recognizers. In FIG. **3**F, receiving gesture recognizers **516-1**, **516-2**, and **516-4** receive the event information, and compare the received event information with a respective gesture definition **3037** (FIG. **3**D) in the receiving gesture recognizers. In FIG. **3**F, gesture recognizers **516-1** and **516-4** have respective gesture definitions that match the received event information, and send respective action messages (e.g., **518-1** and **518-2**) to corresponding gesture handlers (e.g., **552-1** and **552-3**).

FIG. **4**A depicts an event recognizer state machine **400** containing four states. By managing state transitions in event recognizer state machine **400** based on received sub-events, an event recognizer effectively expresses an event definition. For example, a tap gesture may be effectively defined by a sequence of two, or optionally, three sub-events. First, a touch should be detected, and this will be sub-event **1**. For example, the touch sub-event may be a user's finger touching a touch-sensitive surface in a view that includes the event recognizer having state machine **400**. Second, an optional measured delay where the touch does not substantially move in any given direction (e.g., any movement of the touch position is less than a predefined threshold, which may be measured as a distance (e.g., 5 mm) or as a number of pixels (e.g., 5 pixels) on the display), and the delay is sufficiently short, would serve as sub-event **2**. Finally, termination of the touch (e.g., liftoff of the user's finger from the touch-sensitive surface) will serve as sub-event **3**. By coding the event recognizer state machine **400** to transition between states based upon receiving these sub-events, the event recognizer state machine **400** effectively expresses a tap gesture event definition. However, it should be noted that the states depicted in FIG. **4**A are exemplary states, and an event recognizer state machine **400** may contain more or fewer states and/or each state in the event recognizer state machine **400** may correspond to one of the depicted states or any other states.

In some embodiments, regardless of event type, the event recognizer state machine **400** begins in an event recognition begins state **405**, and may progress to any of the remaining states depending on what sub-event is received. To facilitate discussion of the event recognizer state machine **400**, the

direct paths from the event recognition begins state **405** to the event recognized state **415**, the event possible state **410**, and event impossible state **420** will be discussed, followed by a description of the paths leading from the event possible state **410**.

Starting from event recognition begins state **405**, if a sub-event is received that, by itself comprises the event definition for an event, the event recognizer state machine **400** will transition to event recognized state **415**.

Starting from state event recognition begins **405**, if a sub-event is received that is not the first sub-event in an event definition, the event recognizer state machine **400** will transition to event impossible state **420**.

Starting from event recognition begins state **405**, if a sub-event is received that is the first and not final sub-event in a given event definition, the event recognizer state machine **400** will transition to event possible state **410**. If the next sub-event received is a second sub-event, but not the final sub-event in the given event definition, the event recognizer state machine **400** will remain in state event possible **410**. The event recognizer state machine **400** can remain in state event possible **410** for as long as the sequence of received sub-events continues to be part of the event definition. If, at any time the event recognizer state machine **400** is in event possible state **410**, and the event recognizer state machine **400** receives a sub-event that is not part of the event definition, it will transition to state event impossible **420**, thereby determining that the current event (if any) is not the type of event that corresponds to this event recognizer (i.e., the event recognizer corresponding to state **400**). If, on the other hand, the event recognizer state machine **400** is in the event possible state **410**, and the event recognizer state machine **400** receives the last sub-event in an event definition, it will transition to the event recognized state **415**, thereby completing a successful event recognition.

FIG. **4**B depicts an embodiment of an input source handling process **440**, having a finite state machine representing how views receive information about a respective input. It is noted that when there are multiple touches on the touch-sensitive surface of a device, each of the touches is a separate input source having its own finite state machine. In this embodiment, input source handling process **440** includes four states: input sequence begin **445**, input sequence continues **450**, input sequence ended **455**, and input sequence cancelled **460**. Input source handling process **440** may be used by a respective event recognizer, for example, when input is to be delivered to an application, but only after the completion of an input sequence is detected. Input source handling process **440** can be used with an application that is incapable of canceling or undoing changes made in response to an input sequence delivered to the application. It should be noted that the states depicted in FIG. **4**B are exemplary states, and input source handling process **440** may contain more or fewer states and/or each state in input source handling process **440** may correspond to one of the depicted states or any other states.

Starting from input sequence begin **445**, if an input is received that, by itself completes an input sequence, input source handling process **440** will transition to input sequence ended **455**.

Starting from input sequence begin **445**, if an input is received that indicates the input sequence terminated, input source handling process **440** will transition to input sequence cancelled **460**.

Starting from input sequence begin **445**, if an input is received that is the first and not final input in a input sequence, input source handling process **440** will transition to state input sequence continues **450**. If the next input received is the second input in an input sequence, the input handling process **440** will remain in state input sequence continues **450**. Input source handling process **440** can remain in state input sequence continues **450** for as long as the sequence of sub-events being delivered continue to be part of a given input sequence. If, at any time input source handling process **440** is in state input sequence continues **450**, and input source handling process **440** receives an input that is not part of the input sequence, it will transition to state input sequence cancelled **460**. If, on the other hand, input source handling process **440** is in input sequence continues **450**, and the input handling process **440** receives the last input in a given input definition, it will transition to the input sequence ended **455**, thereby successfully receiving a group of sub-events.

In some embodiments, input source handling process **440** may be implemented for particular views or programmatic levels. In that case, certain sequences of sub-events may result in transitioning to state input cancelled **460**.

As an example, consider FIG. **4**C, which supposes an actively involved view, represented only by actively involved view input source handler **480** (hereafter "view **480**"). View **480** includes a vertical swipe event recognizer, represented only by vertical swipe event recognizer **468** (hereafter "recognizer **468**") as one of its event recognizers. In this case, the recognizer **468** may require as part of its definition detecting: 1) a finger down **465-1**; 2) an optional short delay **465-2**; 3), vertical swiping of at least N pixels **465-3**; and 4) a finger liftoff **465-4**.

For this example, the recognizer **468** also has its delay touch began flag **328** and touch cancellation flag **332** set. Now consider delivery of the following sequence of sub-events to recognizer **468**, as well as the view **480**:

- sub-event sequence **465-1**: detect finger down, which corresponds to recognizer **468**'s event definition
- sub-event sequence **465-2**: measure delay, which corresponds to recognizer **468**'s event definition
- sub-event sequence **465-3**: finger performs a vertical swiping movement compatible with vertical scrolling, but is less than N pixels, and therefore does not correspond to recognizer **468**'s event definition
- sub-event sequence **465-4**: detect finger liftoff, which corresponds to recognizer **468**'s event definition

Here, recognizer **468** would successfully recognize sub-events **1** and **2** as part of its event definition, and accordingly, would be in state event possible **472** immediately prior to the delivery of sub-event **3**. Since recognizer **468** has its delay touch began flag **328** set, the initial touch sub-event is not sent to the hit view. Correspondingly, the view **480**'s input source handling process **440** would still be in state input sequence begin immediately prior to the delivery of sub-event **3**.

Once delivery of sub-event **3** to recognizer **468** is complete, recognizer **468**'s state transitions to event impossible **476**, and importantly, the recognizer **468** has now determined that the sequence of sub-events does not correspond to its specific vertical swipe gesture event type (i.e., it has decided the event is not a vertical swipe. In other words, recognition **474** as a vertical swipe does not occur in this example.). The input source handling system **440** for view input source handler **480** will also update its state. In some embodiments, the state of the view input source handler **480** would proceed from the input sequence begins state **482** to the input sequence continues state **484** when the event recognizer sends status information indicating that it has begun recognizing an event. The view input source handler **480** proceeds to the input sequence cancelled state **488** when the touch or input ends without an event being recognized because the touch cancellation flag **322** of the event recognizer has been set. Alternately, if the

touch cancellation flag **322** of the event recognizer had not been set, the view input source handler **480** proceeds to the input sequence ended state **486** when the touch of input ends.

Since event recognizer **468**'s touch cancellation flag **332** is set, when the event recognizer **468** transitions to the event impossible state **476**, the recognizer will send a touch cancellation sub-event or message to the hit view corresponding to the event recognizer. As a result, the view input source handler **480** will transition to the state input sequence cancelled **488**.

In some embodiments, delivery of sub-event **465-4** is not germane to any event recognition decisions made by recognizer **468**, though view input source handler **480**'s other event recognizers, if any, may continue to analyze the sequence of sub-events.

The following table presents in summarized tabular format the processing of this exemplary sub-event sequence **465** as related to the state of event recognizer **468** described above, along with the state of view input source handler **480**. In this example, the state of the view input source handler **480** proceeds from input sequence begin **445** to input sequence cancelled **488** because recognizer **468**'s touch cancellation flag **332** was set:

| Sub-Event Sequence 465 | State: Recognizer 468 | State: View 480 |
|---|---|---|
| before delivery starts | Event Recognition Begins 470 | |
| detect finger down 465-1 | Event Possible 472 | Input Sequence Begins 482 |
| measure delay 465-2 | Event Possible 472 | Input Sequence Continues 484 |
| detect finger vertical swipe 465-3 | Event Impossible 476 | Input Sequence Continues 484 |
| detect finger liftoff 465-4 | Event Impossible 476 | Input Sequence Cancelled 488 |

Turning to FIG. **5**A, attention is directed to an example of a sub-event sequence **520**, which is being received by a view that includes a plurality of event recognizers. For this example, two event recognizers are depicted in FIG. **5**A, scrolling event recognizer **580** and tap event recognizer **590**. For purposes of illustration, the view search results panel **304** in FIG. **3**A will be related to the reception of the sub-event sequence **520**, and the state transitions in scrolling event recognizer **580** and tap event recognizer **590**. Note that in this example, the sequence of sub-events **520** defines a tap finger gesture on a touch-sensitive display or trackpad, but the same event recognition technique could be applied in a myriad of contexts, e.g., detecting a mouse button press, and/or in embodiments utilizing programmatic hierarchies of programmatic levels.

Before the first sub-event is delivered to view search results panel **304**, event recognizers **580** and **590** are in the event recognition begins states **582** and **592**, respectively. Following touch **301**, which is delivered as sub-event detect finger down **521-1** to actively involved event recognizers for view search results panel **304** as touch sub-event **301-2** (as well as to actively involved event recognizers for map view **305** as touch sub-event **301-3**), scrolling event recognizer **580** transitions to state event possible **584**, and similarly, tap event recognizer **590** transitions to state event possible **594**. This is because the event definition of a tap and a scroll both begin with a touch such as detecting a finger down on a touch-sensitive surface.

Some definitions of tap and scroll gestures may optionally include a delay between an initial touch and any next step in the event definition. In all examples discussed here, the exemplar event definitions for both tap and scroll gestures recognize a delay sub-event following the first touch sub-event (detect finger down).

Accordingly, as sub-event measure delay **521-2** is delivered to event recognizers **580** and **590**, both remain in the event possible states **584** and **594**, respectively.

Finally, sub-event detect finger liftoff **521-3** is delivered to event recognizers **580** and **590**. In this case, the state transitions for event recognizers **580** and **590** are different, because the event definitions for tap and scroll are different. In the case of scrolling event recognizer **580**, the next sub-event to remain in state event possible would be to detect movement. Since the sub-event delivered is detect finger liftoff **521-3**, however, the scrolling event recognizer **580** transitions to state event impossible **588**. A tap event definition concludes with a finger liftoff sub-event though. Accordingly, tap event recognizer **590** transitions to state event recognized **596** after sub-event detect finger liftoff **521-3** is delivered.

Note that in some embodiments, as discussed above with respect to FIGS. **4**B and **4**C, the input source handling process **440** discussed in FIG. **4**B may be used for various purposes at the view level. The following table presents in summarized tabular format the delivery of sub-event sequence **520** as related to event recognizers **580**, **590**, and input source handling process **440**:

| Sub-Event Sequence 520 | State: Scrolling Event Recognizer 580 | State: Tap Event Recognizer 590 | State: Input Source Handling Process 440 |
|---|---|---|---|
| before delivery starts | Event Recognition Begins 582 | Event Recognition Begins 592 | |
| Detect Finger Down 521-1 | Event Possible 584 | Event Possible 594 | Input Sequence Begin 445 |
| Measure Delay 521-2 | Event Possible 584 | Event Possible 594 | Input Sequence Continues 450 |
| Detect Finger Liftoff 521-3 | Event impossible 588 | Event Recognized 596 | Input Sequence Ended 455 |

Turning to FIG. **5**B, attention is directed to another example of a sub-event sequence **530**, which is being received by a view that includes a plurality of event recognizers. For this example, two event recognizers are depicted in FIG. **5**B, scrolling event recognizer **580** and tap event recognizer **590**. For purposes of illustration, the view search results panel **304** in FIG. **3**A will be related to the reception of the sub-event sequence **530**, and the state transitions in scrolling event recognizer **580** and tap event recognizer **590**. Note that in this example, the sequence of sub-events **530** defines a scroll finger gesture on a touch-sensitive display, but the same event recognition technique could be applied in myriad contexts, e.g., detecting a mouse button press, mouse movement, and mouse button release, and/or in embodiments utilizing programmatic hierarchies of programmatic levels.

Before the first sub-event is delivered to actively involved event recognizers for view search results panel **304**, event recognizers **580** and **590** are in the event recognition begins states **582** and **592**, respectively. Following delivery of sub-events corresponding to touch **301** (as discussed above), scrolling event recognizer **580** transitions to state event possible **584**, and similarly, tap event recognizer **590** transitions to state event possible **594**.

As sub-event measure delay **531-2** is delivered to event recognizers **580** and **590**, both transition to the event possible states **584** and **594**, respectively.

Next, sub-event detect finger movement **531-3** is delivered to event recognizers **580** and **590**. In this case, the state transitions for event recognizers **580** and **590** are different

because the event definitions for tap and scroll are different. In the case of scrolling event recognizer **580**, the next sub-event to remain in state event possible is to detect movement, so the scrolling event recognizer **580** remains in the event possible state **584** when it receives sub-event detect finger movement **531-3**. As discussed above, however, the definition for a tap concludes with a finger liftoff sub-event, so tap event recognizer **590** transitions to the state event impossible **598**.

Finally, sub-event detect finger liftoff **531-4** is delivered to event recognizers **580** and **590**. Tap event recognizer is already in the event impossible state **598**, and no state transition occurs. Scrolling event recognizer **580**'s event definition concludes with detecting a finger liftoff. Since the sub-event delivered is detect finger liftoff **531-4**, the scrolling event recognizer **580** transitions to state event recognized **586**. It is noted that a finger movement on a touch sensitive surface may generate multiple movement sub-events, and therefore a scroll may be recognized before liftoff and continue until liftoff.

The following table presents in summarized tabular format the delivery of sub-event sequence **530** as related to event recognizers **580**, **590**, and input source handling process **440**:

| Sub-Event Sequence 530 | State: Scrolling Event Recognizer 580 | State: Tap Event Recognizer 590 | State: Input Source Handling Process 440 |
|---|---|---|---|
| before delivery starts | Event Recognition Begins 582 | Event Recognition Begins 592 | |
| detect finger down 531-1 | Event Possible 584 | Event Possible 594 | Input Sequence Begins 445 |
| measure delay 531-2 | Event Possible 584 | Event Possible 594 | Input sequence continues 450 |
| detect finger movement 531-3 | Event Possible 584 | Event Impossible 598 | Input sequence continues 450 |
| detect finger liftoff 531-4 | Event Recognized 586 | Event Impossible 598 | Input sequence ended 455 |

Turning to FIG. **5**C, attention is directed to another example of a sub-event sequence **540**, which is being received by a view that includes a plurality of event recognizers. For this example, two event recognizers are depicted in FIG. **5**C, double tap event recognizer **570** and tap event recognizer **590**. For purposes of illustration, the map view **305** in FIG. **3**A will be related to the reception of the sub-event sequence **540**, and the state transitions in double tap event recognizer **570** and tap event recognizer **590**. Note that in this example, the sequence of sub-events **540** defines a double tap gesture on a touch-sensitive display, but the same event recognition technique could be applied in myriad contexts, e.g., detecting a mouse double click, and/or in embodiments utilizing programmatic hierarchies of programmatic levels.

Before the first sub-event is delivered to actively involved event recognizers for map view **305**, event recognizers **570** and **590** are in the event recognition begins states **572** and **592**, respectively. Following delivery of sub-events related to touch sub-event **301** to map view **304** (as described above), double tap event recognizer **570** and tap event recognizer **590** transition to states event possible **574** and **594**, respectively. This is because the event definition of a tap and a double tap both begin with a touch such as detecting a finger down **541-1** on a touch-sensitive surface.

As sub-event measure delay **541-2** is delivered to event recognizers **570** and **590**, both remain in states event possible **574** and **594**, respectively.

Next, sub-event detect finger liftoff **541-3** is delivered to event recognizers **570** and **590**. In this case, the state transitions for event recognizers **580** and **590** are different because the exemplar event definitions for tap and double tap are different. In the case of tap event recognizer **590**, the final sub-event in the event definition is to detect finger liftoff, so the tap event recognizer **590** transitions to the event recognized state **596**.

Double tap recognizer **570** remains in state event possible **574**, however, since a delay has begun, regardless of what the user may ultimately do. The complete event recognition definition for a double tap requires another delay, followed by a complete tap sub-event sequence though. This creates an ambiguous situation as between the tap event recognizer **590**, which is already in state event recognized **576**, and the double tap recognizer **570**, which is still in state event possible **574**.

Accordingly, in some embodiments, event recognizers may implement exclusivity flags and exclusivity exception lists as discussed above with respect to FIGS. **3**B and **3**C. Here, the exclusivity flag **324** for tap event recognizer **590** would be set, and additionally, exclusivity exception list **326** for tap event recognizer **590** would be configured to continue permitting delivery of sub-events to some event recognizers (such as double tap event recognizer **570**) after tap event recognizer **590** enters the state event recognized **596**.

While tap event recognizer **590** remains in state event recognized **596**, sub-event sequence **540** continues to be delivered to double tap event recognizer **570**, where sub-events measure delay **541-4**, detect finger down **541-5**, and measure delay **541-6**, keep the double tap event recognizer **570** in the state event possible **574**; delivery of the final sub-event of sequence **540**, detect finger liftoff **541-7** transitions double tap event recognizer **570** to state event recognized **576**.

At this point, the map view **305** takes the event double tap as recognized by event recognizer **570**, rather than the single tap event recognized by tap event recognizer **590**. The decision to take the double tap event is made in light of the combination of the tap event recognizer **590**'s exclusivity flag **324** being set, the tap event recognizer **590**'s exclusivity exception list **326** including a double tap event, and the fact that both the tap event recognizer **590** and the double tap event recognizer **570** both successfully recognized their respective event types.

The following table presents in summarized tabular format the delivery of sub-event sequence **540** as related to event recognizers **570** and **590**, and sub-event handling process **440**:

| Sub-Event Sequence 540 | State: Double Tap Event Recognizer 570 | State: Tap Event Recognizer 590 | State: Input Source Handling Process 440 |
|---|---|---|---|
| before delivery starts | Event Recognition Begins 572 | Event Recognition Begins 592 | |
| detect finger down 541-1 | Event Possible 574 | Event Possible 594 | Input Sequence Begins 445 |
| measure delay 541-2 | Event Possible 574 | Event Possible 594 | Input sequence continues 450 |
| detect finger liftoff 541-3 | Event Possible 574 | Event Recognized 596 | Input sequence continues 450 |
| measure delay 541-4 | Event Possible 574 | Event Recognized 596 | Input sequence continues 450 |
| detect finger down 541-5 | Event Possible 574 | Event Recognized 596 | Input sequence continues 450 |
| measure delay 541-6 | Event Possible 574 | Event Recognized 596 | Input sequence continues 450 |
| detect finger liftoff 541-7 | Event Recognized 576 | Event Recognized 596 | Input sequence ended 455 |

In another embodiment, in the event scenario of FIG. **5**C, the single tap gesture is not recognized, because the single tap event recognizer has a wait-for list that identifies the double tap event recognizer. As a result, a single tap gesture is not recognized until (if ever) the double tap event recognizer enters the event impossible state. In this example, in which a double tap gesture is recognized, the single tap event recognizer would remain in the event possible state until the double tap gesture is recognized, at which point the single tap event recognizer would transition to the event impossible state.

Attention is now directed to FIGS. **6**A and **6**B, which are flow diagrams illustrating an event recognition method in accordance with some embodiments. The method **600** is performed at an electronic device, which in some embodiments, may be an electronic device **102**, as discussed above. In some embodiments, the electronic device may include a touch sensitive surface configured to detect multi-touch gestures. Alternatively, the electronic device may include a touch screen configured to detect multi-touch gestures.

The method **600** is configured to execute software that includes a view hierarchy with a plurality of views. The method **600** displays **608** one or more views of the view hierarchy, and executes **610** one or more software elements. Each software element is associated with a particular view, and each particular view includes one or more event recognizers, such as those described in FIGS. **3**B and **3**C as event recognizer structures **320** and **360**, respectively.

Each event recognizer generally includes an event definition based on one or more sub-events, where the event definition may be implemented as a state machine, see e.g., FIG. **3**B state machine **340**. Event recognizers also generally include an event handler, which specifies an action for a target, and is configured to send the action to the target in response to the event recognizer detecting an event corresponding to the event definition.

In some embodiments, at least one of the plurality of event recognizers is a gesture recognizer having a gesture definition and a gesture handler as noted in step **612** of FIG. **6**A.

In some embodiments, the event definition defines a user gesture as noted in step **614** of FIG. **6**A.

Alternatively, event recognizers have a set of event recognition states **616**. These event recognition states may include at least an event possible state, an event impossible state, and an event recognized state.

In some embodiments, the event handler initiates preparation **618** of its corresponding action for delivery to the target if the event recognizer enters the event possible state. As discussed above with respect to FIG. **4**A and the examples in FIGS. **5**A-**5**C, the state machines implemented for each event recognizer generally include an initial state, e.g., state event recognition begins **405**. Receiving a sub-event that forms the initial part of an event definition triggers a state change to the event possible state **410**. Accordingly, in some embodiments, as an event recognizer transitions from the state event recognition begins **405** to the state event possible **410**, the event recognizer's event handler may begin preparing its particular action to deliver to the event recognizer's target after an event is successfully recognized.

On the other hand, in some embodiments, the event handler may terminate preparation **620** of its corresponding action if the event recognizer enters the state event impossible **420**. In some embodiments, terminating the corresponding action includes canceling any preparation of the event handler's corresponding action.

The example of FIG. **5**B is informative for this embodiment since tap event recognizer **590** may have initiated preparation **618** of its action, but then, once the sub-event detect finger movement **531-3** is delivered to the tap event recognizer **590**, the recognizer **590** will transition to the event impossible state **598**, **578**. At that point, tap event recognizer **590** may terminate preparation **620** of the action for which it had initiated preparation **618**.

In some embodiments, the event handler completes preparation **622** of its corresponding action for delivery to the target if the event recognizer enters the event recognized state. The example of FIG. **5**C illustrates this embodiment since a double tap is recognized by actively involved event recognizers for the map view **305**, which in some implementations, would be the event bound to selecting and/or executing the search result depicted by map view **305**. Here, after the double tap event recognizer **570** successfully recognizes the double tap event comprised of the sub-event sequence **540**, map view **305**'s event handler completes preparation **622** of its action, namely, indicating that it has received an activation command.

In some embodiments, the event handler delivers **624** its corresponding action to the target associated with the event recognizer. Continuing with the example of FIG. **5**C, the action prepared, i.e. the activation command of the map view **305**, would be delivered to the specific target associated with the map view **305**, which may be any suitable programmatic method or object.

Alternatively, the plurality of event recognizers may independently process **626** the sequence of one or more sub-events in parallel.

In some embodiments, one or more event recognizers may be configured as exclusive event recognizers **628**, as discussed above with respect to FIGS. **3**B and **3**C's exclusivity flags **324** and **364**, respectively. When an event recognizer is configured as an exclusive event recognizer, the event delivery system prevents any other event recognizers for actively involved views (except those listed in the exception list **326**, **366** of the event recognizer that recognizes the event) in the view hierarchy from receiving subsequent sub-events (of the same sequence of sub-events) after the exclusive event recognizer recognizes an event. Furthermore, when a non-exclusive event recognizer recognizes an event, the event delivery system prevents any exclusive event recognizers for actively involved views in the view hierarchy from receiving subsequent sub-events, except for those (if any) listed in the exception list **326**, **366** of the event recognizer that recognizes the event.

In some embodiments, exclusive event recognizers may include **630** an event exception list, as discussed above with respect to FIGS. **3**B and **3**C's exclusivity exception lists **326** and **366**, respectively. As noted in the discussion of FIG. **5**C above, an event recognizer's exclusivity exception list can be used to permit event recognizers to continue with event recognition even when the sequence of sub-events making up their respective event definitions overlap. Accordingly, in some embodiments, the event exception list includes events whose corresponding event definitions have repetitive sub-events **632**, such as the single tap/double tap event example of FIG. **5**C.

Alternately, the event definition may define a user input operation **634**.

In some embodiments, one or more event recognizers may be adapted to delay delivering every sub-event of the sequence of sub-events until after the event is recognized.

The method **600** detects **636** a sequence of one or more sub-events, and in some embodiments, the sequence of one or more sub-events may include primitive touch events **638**. Primitive touch events may include, without limitation, basic components of a touch-based gesture on a touch-sensitive

surface, such as data related to an initial finger or stylus touch down, data related to initiation of multi-finger or stylus movement across a touch-sensitive surface, dual finger movements in opposing directions, stylus lift off from a touch-sensitive surface, etc.

Sub-events in the sequence of one or more sub-events can include many forms, including without limitation, key presses, key press holds, key press releases, button presses, button press holds, button press releases, joystick movements, mouse movements, mouse button presses, mouse button releases, pen stylus touches, pen stylus movements, pen stylus releases, oral instructions, detected eye movements, biometric inputs, and detected physiological changes in a user, among others.

The method **600** identifies **640** one of the views of the view hierarchy as a hit view. The hit view establishes which views in the view hierarchy are actively involved views. An example is depicted in FIG. **3**A, where the actively involved views **303** include search results panel **304**, and maps view **305** because touch sub-event **301** contacted the area associated with the maps view **305**.

In some embodiments, a first actively involved view within the view hierarchy may be configured **642** to prevent delivery of the respective sub-event to event recognizers associated with that first actively involved view. This behavior can implement the skip property discussed above with respect to FIGS. **3**B and **3**C (**330** and **370**, respectively). When the skip property is set for an event recognizer, delivery of the respective sub-event is still performed for event recognizers associated with other actively involved views in the view hierarchy.

Alternately, a first actively involved view within the view hierarchy may be configured **644** to prevent delivery of the respective sub-event to event recognizers associated with that first actively involved view unless the first actively involved view is the hit view. This behavior can implement the conditional skip property discussed above with respect to FIGS. **3**B and **3**C (**332** and **372**, respectively).

In some embodiments, a second actively involved view within the view hierarchy is configured **646** to prevent delivery of the respective sub-event to event recognizers associated with the second actively involved view and to event recognizers associated with ancestors of the second actively involved view. This behavior can implement the stop property discussed above with respect to FIGS. **3**B and **3**C (**328** and **368**, respectively).

The method **600** delivers **648** a respective sub-event to event recognizers for each actively involved view within the view hierarchy. In some embodiments, event recognizers for actively involved views in the view hierarchy process the respective sub-event prior to processing a next sub-event in the sequence of sub-events. Alternately, event recognizers for the actively involved views in the view hierarchy make their sub-event recognition decisions while processing the respective sub-event.

In some embodiments, event recognizers for actively involved views in the view hierarchy may process the sequence of one or more sub-events concurrently **650**; alternatively, event recognizers for actively involved views in the view hierarchy may process the sequence of one or more sub-events in parallel.

In some embodiments, one or more event recognizers may be adapted to delay delivering **652** one or more sub-events of the sequence of sub-events until after the event recognizer recognizes the event. This behavior reflects a delayed event. For example, consider a single tap gesture in a view for which multiple tap gestures are possible. In that case, a tap event becomes a "tap+delay" recognizer. In essence, when an event recognizer implements this behavior, the event recognizer will delay event recognition until it is certain that the sequence of sub-events does in fact correspond to its event definition. This behavior may be appropriate when a recipient view is incapable of appropriately responding to cancelled events. In some embodiments, an event recognizer will delay updating its event recognition status to its respective actively involved view until the event recognizer is certain that the sequence of sub-events does not correspond to its event definition. As discussed above with respect to FIGS. **3**B and **3**C, delay touch began flag **328**, **368**, delay touch end flag **330**, **370**, and touch cancellation flag **332**, **372** are provided to tailor sub-event delivery techniques, as well as event recognizer and view status information updates to specific needs.

FIGS. **7**A-**7**S illustrate exemplary user interfaces and user inputs recognized by event recognizers for navigating through concurrently open applications in accordance with some embodiments. The user interfaces in these figures are used to illustrate the processes described below, including the processes in FIGS. **8**A-**8**B, FIGS. **9**A-**9**C, and FIGS. **10**A-**10**B.

Although many of the examples which follow will be given with reference to inputs on touch screen display **156** (where the touch sensitive surface and the display are combined), in some embodiments, the device detects inputs on a touch-sensitive surface that is separate from the display (e.g., a touchpad or trackpad). In some embodiments the touch-sensitive surface has a primary axis that corresponds to a primary axis on the display. In accordance with these embodiments, the device detects contacts with the touch-sensitive surface at locations that correspond to respective locations on the display. In this way, user inputs detected by the device on the touch-sensitive surface are used by the device to manipulate the user interface on the display of the electronic device when the touch-sensitive surface is separate from the display. It should be understood that similar methods may be used for other user interfaces described herein.

FIG. **7**A illustrates an exemplary user interface ("home screen" **708**) on electronic device **102** in accordance with some embodiments. Similar user interfaces may be implemented on electronic devices **102**. In some embodiments, home screen **708** is displayed by an application launcher software application, sometimes called a springboard. In some embodiments, the user interface on touch screen **156** includes the following elements, or a subset or superset thereof:

Signal strength indicator(s) **702** for wireless communication(s), such as cellular and Wi-Fi signals;

Time **704**; and

Battery status indicator **706**.

The exemplary user interface includes a plurality of application icons **5002** (e.g., **5002-25** through **5002-38**). From the home screen **708**, a finger gesture can be used to launch an application. For example, tap finger gesture **701** at a location that corresponds to application icon **5002-36** initiates launching an email application.

In FIG. **7**B, in response to detecting the finger gesture **701** on application icon **5002-36**, the email application is launched and email application view **712-1** is displayed on touch screen **156**. A user may launch other applications in a similar manner. For example, a user may press home button **710** from any application view **712** to return to home screen **708** (FIG. **7**A), and launch other applications with finger gestures on respective application icons **5002** on home screen **708**.

FIGS. **7**C-**7**G illustrate that respective applications are sequentially launched in response to detecting respective fin-

ger gestures at locations corresponding to respective application icons **5002** on home screen **708**, and that respective user interfaces (i.e., respective application views) are displayed in turn. In particular, FIG. **7**C illustrates that media store application view **712-2** is displayed in response to a finger gesture on application icon **5002-32**. In FIG. **7**D, notes application view **712-3** is displayed in response to a finger gesture on application icon **5002-30**. FIG. **7**E illustrates that map application view **712-4** is displayed in response to a finger gesture on application icon **5002-27**. In FIG. **7**F, weather application view **712-5** is displayed in response to a finger gesture on application icon **5002-28**. FIG. **7**G illustrates that web browser application view **712-6** is displayed in response to a finger gesture on application icon **5002-37**. In some embodiments, a sequence of open applications corresponds to the launching of an email application, a media store application, a notes application, a map application, a weather application, and a web browser application.

FIG. **7**G also illustrates a finger gesture **703** (e.g., a tap gesture) on a user interface object (e.g., a bookmark icon). In some embodiments, in response to detecting the finger gesture **703** on the bookmark icon, the web browser application displays a list of bookmarks on touch screen **156**. Similarly, a user may interact with a displayed application (e.g., the web browser application) with other gestures (e.g., a tap gesture on the address user interface object, which allows the user to type in a new address or modify the displayed address, typically with an on-screen keyboard; a tap gesture on any of links in the displayed web page, which initiates navigating to a web page corresponding to the selected link; etc.).

In FIG. **7**G, a first predefined input (e.g., a double-click **705** on home button **710**) is detected. Alternatively, a multi-finger swipe gesture (e.g., a three-finger swipe-up gesture as illustrated with movements of finger contacts **707**, **709**, and **711**) is detected on touch screen **156**.

FIG. **7**H illustrates that, in response to detecting the first predefined input (e.g., double-click **705** or the multi-finger swipe gesture including finger contacts **707**, **709**, and **711**), a portion of web browser application view **712-6** and application icon area **716** are concurrently displayed. In some embodiments, in response to detecting the first predefined input, the device enters into an application view selection mode for selecting one of the concurrently open applications, and the portion of web browser application view **712-6** and application icon area **716** are concurrently displayed as part of the application view selection mode. Application icon area **716** includes a group of open application icons that correspond to at least some of the plurality of concurrently open applications. In this example, the portable electronic device has multiple applications that are concurrently open (e.g., the email application, the media store application, the notes application, the map application, the weather application, and the web browser application), although they are not all simultaneously displayed. As illustrated in FIG. **7**H, application icon area **506** includes application icons (e.g., **5004-2**, **5004-4**, **5004-6**, and **5004-8**) for the weather application, the map application, the notes application, and the media store application (i.e., four applications that immediately follow the currently displayed application, the web browser application, in the sequence of open applications). In some embodiments, the sequence or order of open application icons displayed in application icon area **716** corresponds to the sequence of open applications in the predetermined sequence (e.g., weather, map, notes, and media store applications).

FIG. **7**H also illustrates that gesture **713** (e.g., a tap gesture) is detected on open application icon **5004-8**. In some embodiments, in response to detecting gesture **713**, a corresponding application view (e.g., media store application view **712-2**, FIG. **7**C) is displayed.

FIG. **7**H illustrates that a left-swipe gesture **715** is detected at a location corresponding to application icon area **716**. In FIG. **7**I, in response to detecting left-swipe gesture **715**, the application icons (e.g., **5004-2**, **5004-4**, **5004-6**, and **5004-8**) in application icon area **716** are scrolled. As a result of scrolling, application icon **5004-12** for the email application is displayed in application icon area **506** instead of previously displayed application icons (e.g., **5004-2**, **5004-4**, **5004-6**, and **5004-8**).

In FIG. **7**J, a gesture of a first type (e.g., a multi-finger left-swipe gesture including movements of finger contacts **717**, **719**, and **721**) is detected on web browser application view **712-6**. FIG. **7**K illustrates that, in response to detecting the gesture of the first type, weather application view **712-5** is displayed on touch screen **156**. It should be noted that the weather application is next to the web browser application in the sequence of open applications.

FIG. **7**K also illustrates that a second gesture of the first type (e.g., a multi-finger left-swipe gesture including movements of finger contacts **723**, **725**, and **727**) is detected on weather application view **712-5**. FIG. **7**L illustrates that, in response to detecting the second gesture of the first type, map application view **712-4** is displayed on touch screen **156**. It should be noted that the map application is next to the weather application in the sequence of open applications.

FIG. **7**L also illustrates that a third gesture of the first type (e.g., a multi-finger left-swipe gesture including movements of finger contacts **729**, **731**, and **733**) is detected on map application view **712-4**. FIG. **7**M illustrates that, in response to detecting the third gesture of the first type, notes application view **712-3** is displayed on touch screen **156**. It should be noted that the notes application is next to the map application in the sequence of open applications.

FIG. **7**M also illustrates that a fourth gesture of the first type (e.g., a multi-finger left-swipe gesture including movements of finger contacts **735**, **737**, and **739**) is detected on notes application view **712-3**. FIG. **7**N illustrates that, in response to detecting the fourth gesture of the first type, media store application view **712-2** is displayed on touch screen **156**. It should be noted that the media store application is next to the notes application in the sequence of open applications.

FIG. **7**N also illustrates that a fifth gesture of the first type (e.g., a multi-finger left-swipe gesture including movements of finger contacts **741**, **743**, and **745**) is detected on media store application view **712-2**. FIG. **7**O illustrates that, in response to detecting the fifth gesture of the first type, email application view **712-1** is displayed on touch screen **156**. It should be noted that the email application is next to the media store application in the sequence of open applications.

FIG. **7**O also illustrates that a sixth gesture of the first type (e.g., a multi-finger left-swipe gesture including movements of finger contacts **747**, **749**, and **751**) is detected on email application view **712-1**. FIG. **7**P illustrates that, in response to detecting the sixth gesture of the first type, web browser application view **712-6** is displayed on touch screen **156**. It should be noted that the web browser application is on one end of the sequence of open applications, and the email application is on the opposite end of the sequence of open applications.

FIG. **7**P also illustrates that a gesture of a second type (e.g., a multi-finger right-swipe gesture including movements of finger contacts **753**, **755**, and **757**) is detected on web browser application view **712-6**. FIG. **7**Q illustrates that, in some

embodiments, in response to detecting the gesture of the second type, email application view **712-1** is displayed on touch screen **156**.

Referring to FIG. **7**R, a multi-finger gesture (e.g., a five-finger pinch gesture including movements of finger contacts **759**, **761**, **763**, **765**, and **767**) is detected on web browser application view **712-6**. FIG. **7**S illustrates that, while detecting the multi-finger gesture on touch screen **156**, web browser application view **712-6** and at least a portion of home screen **708** are concurrently displayed. As illustrated, web browser application view **712-6** is displayed at a reduced scale. The reduced scale is adjusted in accordance with the multi-finger gesture while the multi-finger gesture is detected on the touch screen **156**. For example, the reduced scale decreases with further pinching of finger contacts **759**, **761**, **763**, **765**, and **767** (i.e., web browser application view **712-6** is displayed at a smaller scale). Alternatively, the reduced scale increases with depinching of finger contacts **759**, **761**, **763**, **765**, and **767** (i.e., web browser application view **712-6** is displayed at a larger scale than before).

In some embodiments, when the multi-finger gesture ceases to be detected, web browser application view **712-6** ceases to be displayed, and the entire home screen **708** is displayed. Alternatively, when the multi-finger gesture ceases to be detected, it is determined whether the entire home screen **708** is to be displayed or web browser application view **712-6** is to be displayed at a full-screen scale. In some embodiments, the determination is made based on the reduced scale when the multi-finger gesture ceases to be displayed (e.g., if the application view is displayed at a scale smaller than a predefined threshold when the multi-finger gesture ceases to be detected, the entire home screen **708** is displayed; if the application view is displayed at a scale larger than the predefined threshold when the multi-finger gesture ceases to be detected, the application view is displayed at a full-screen scale without a display of home screen **708**). In some embodiments, the determination is made also based on the speed of the multi-finger gesture.

FIGS. **8**A and **8**B are flow diagrams illustrating event recognition method **800** in accordance with some embodiments. Method **800** is performed (**802**) at an electronic device with a touch-sensitive display (e.g., device **102**, FIG. **1**B). The electronic device is configured to execute at least a first software application and a second software application. The first software application includes a first set of one or more gesture recognizers, and the second software application includes one or more views and a second set of one or more gesture recognizers (e.g., application **133-2** has gesture recognizer **516-4**, and application **133-1** has gesture recognizers **516-1** through **516-3** and views **508**, **510**, and **512**, FIG. **3**F). Respective gesture recognizers have corresponding gesture handlers (e.g., gesture handler **552-1** corresponds to gesture recognizer **516-1** and gesture handler **552-3** corresponds to gesture recognizer **516-4**). The first set of one or more gesture recognizers is typically different from the second set of one or more gesture recognizers.

Method **800** allows a user to control with a gesture a hidden open application that is not currently displayed on a display of the electronic device (e.g., the first software application), such as a background application, a suspended application, or a hibernated application. Thus, the user can perform operations that are not provided by the application currently displayed on the display of the electronic device (e.g., the second software application) but are provided by one of the currently open applications (e.g., displaying a home screen or switching to a next software application using gestures for a hidden application launcher software application).

In some embodiments, the first software application is (**804**) an application launcher (e.g., a springboard). For example, as shown in FIG. **7**A, the application launcher displays a plurality of application icons **5002** that correspond to a plurality of applications. The application launcher receives a user-selection of an application icon **5002** (e.g., based on a finger gesture on touch screen **156**), and in response to receiving the user-selection, launches an application corresponding to the selected application icon **5002**.

The second software application is typically a software application launched by the application launcher. As illustrated in FIGS. **7**A and **7**B, the application launcher receives information about tap gesture **701** on email application icon **5002-36**, and launches an email application. In response, the email application displays email application view **712-1** on touch screen **156**. The second application may be any application that corresponds to application icons **5002** (FIG. **7**A) or any other application that can be launched by the application launcher (e.g., media store application, FIG. **7**C; notes application, FIG. **7**D; map application, FIG. **7**E; weather application, **7**F; web browser application, FIG. **7**G; etc.). In the following description of method **800**, an application launcher is used as an exemplary first software application and a web browser application is used as an exemplary second software application.

In some embodiments, the electronic device has only two software applications in the programmatic hierarchy: an application launcher and one other software application (typically a software application corresponding to one or more views displayed on touch screen **156** of electronic device **102**).

In some embodiments, the first software application is (**806**) an operating system application. As used herein, an operating system application refers to an application that is integrated with an operating system **118** (FIGS. **1**A-**1**C). An operating system application typically resides in core OS level **208** or operating system API software **206** in FIG. **2**. An operating system application is typically not removable by a user, whereas other applications typically may be installed or removed by the user. In some embodiments, the operating system application includes the application launcher. In some embodiments, the operating system application includes a settings application (e.g., an application for displaying/modifying system settings or one or more values in device/global internal state **134**, FIG. **1**C). In some embodiments, the operating system application includes accessibility module **127**. In some embodiments, the electronic device has only three software applications in the programmatic hierarchy: an application launcher, a settings application, and one other application (typically a software application corresponding to one or more views displayed on touch screen **156** of electronic device **102**).

The electronic device displays (**808**) at least a subset of the one or more views of the second software application (e.g., web browser application view **712-6**, FIG. **7**G).

In some embodiments, the displaying includes (**810**) displaying at least a subset of the one or more views of the second software application without displaying any view of the first software application. For example, in FIG. **7**G, no view of the application launcher (e.g., home screen **708**) is displayed.

In some embodiments, the displaying includes (**812**) displaying at least a subset of the one or more views of the second software application without displaying a view of any other application. For example, in FIG. **7**G, only one or more views of the web browser application are displayed.

While displaying at least the subset of the one or more views of the second software application, the electronic

device detects (**814**) a sequence of touch inputs on the touch-sensitive display (e.g., gesture **703**, which includes a touch-down event and a touch-up event; or another gesture, which includes touch-down of finger contacts **707**, **709**, and **711**, movements of finger contacts **707**, **709**, and **711** across touch screen **156**, and lift-off of finger contacts **707**, **709**, and **711**). The sequence of touch inputs includes a first portion of one or more touch inputs and a second portion of one or more touch inputs subsequent to the first portion. As used herein, the term "sequence" refers to the order in which one or more touch events happens. For example, in the sequence of touch inputs including finger contacts **707**, **709**, and **711**, the first portion may include the touch-down of finger contacts **707**, **709**, and **711**, and the second portion may include the movements of finger contacts **707**, **709**, and **711**, and lift-off of finger contacts **707**, **709**, and **711**.

In some embodiments, the detecting occurs (**816**) while touch inputs in the first portion of one or more touch inputs at least partially overlap at least one of the displayed views of the second software application. In some embodiments, even though the touch inputs at least partially overlap at least one of the displayed views of the second software application, the first software application receives the first portion of one or more touch inputs. For example, the application launcher receives the first portion of touch inputs on the displayed views of the web browser (FIG. **7**G), even though the application launcher is not displayed.

During a first phase of detecting the sequence of touch inputs (**818**), the electronic device delivers (**820**) the first portion of one or more touch inputs to the first software application and the second software application (e.g., using event dispatcher module **315**, FIG. **3**D), identifies (**822**) from gesture recognizers in the first set, one or more matching gesture recognizers that recognize the first portion of one or more touch inputs (e.g., using event comparator **3033** in each gesture recognizer (typically, each receiving gesture recognizer) in the first set, FIG. **3**D), and processes (**824**) the first portion of one or more touch inputs with one or more gesture handlers corresponding to the one or more matching gesture recognizers (e.g., activating corresponding event handler(s) **319**, FIG. **3**D).

In some embodiments, the first phase of detecting the sequence of touch inputs is a phase of detecting the first portion of one or more touch inputs.

Regarding the delivering operation (**820**), in some embodiments, the first software application, after receiving the first portion of one or more inputs, delivers the first portion of one or more touch inputs to at least a subset of gesture recognizers in the first set, and the second software application, after receiving the first portion of one or more inputs, delivers the first portion of one or more touch inputs to at least a subset of gesture recognizers in the second set. In some embodiments, the electronic device or an event dispatcher module (e.g., **315**, FIG. **3**D) in the electronic device delivers the first portion of one or more touch inputs to at least a subset of gesture recognizers in the first set and the second set (e.g., event dispatcher module **315** delivers the first portion of one or more touch inputs to gesture recognizers **516-1**, **516-2**, and **516-4**, FIG. **3**F).

For example, when the finger gesture including finger contacts **707**, **709**, and **711** is detected on touch screen **156** (FIG. **7**G), the touch-down event is delivered to one or more gesture recognizers of the application launcher and one or more gesture recognizers of the web browser application. In another example, a touch-down event of tap gesture **703** (FIG. **7**G) is delivered to one or more gesture recognizers of the application launcher and one or more gesture recognizers of the web browser application.

In some embodiments, when no gesture recognizer in the first set recognizes the first portion of one or more touch inputs (e.g., a mismatch between detected events and the gesture definition or the gesture is not completed), processing the first portion of one or more touch inputs includes performing a null operation (e.g., the device does not update the displayed user interface).

In some embodiments, the electronic device identifies from gesture recognizers in the second set, one or more matching gesture recognizers that recognizer the first portion of one or more touch inputs. The electronic device processes the first portion of one or more touch inputs with one or more gesture handlers corresponding to the one or more matching gesture recognizers. For example, in response to tap gesture **703** (FIG. **7**G) delivered to one or more gesture recognizers of the web browser application, a matching gesture recognizer in the web browser application (e.g., a gesture recognizer that recognizes a tap gesture on the bookmark icon, FIG. **7**G) processes tap gesture **703** by displaying a list of bookmarks on touch screen **156**.

In some embodiments, during a second phase of detecting the sequence of touch inputs, subsequent to the first phase, the electronic device delivers (**826**, FIG. **8**B) the second portion of one or more touch inputs to the first software application without delivering the second portion of one or more touch inputs to the second software application (e.g., using event dispatcher module **315**, FIG. **3**D), identifies from the one or more matching gesture recognizers a second matching gesture recognizer that recognizes the sequence of touch inputs (e.g., using event comparator **3033** in each matching gesture recognizer, FIG. **3**D), and processes the sequence of touch inputs with a gesture handler corresponding to the respective matching gesture recognizer. In some embodiments, the second phase of detecting the sequence of touch inputs is a phase of detecting the second portion of one or more touch inputs.

For example, when the finger gesture including finger contacts **707**, **709**, and **711** is detected on touch screen **156** (FIG. **7**G), the touch movement and lift-off events are delivered to one or more gesture recognizers of the application launcher without delivering the touch events to the web browser application. The electronic device identifies a matching gesture recognizer (e.g., a three-finger swipe-up gesture recognizer) of the application launcher, and processes the sequence of touch inputs with a gesture handler corresponding to the three-finger swipe-up gesture recognizer.

The second software application does not receive the second portion of one or more touch inputs during the second phase, typically because the first software application has a priority over the second software application (e.g., in the programmatic hierarchy). Thus, in some embodiments, when a gesture recognizer in the first software application recognizes the first portion of one or more touch inputs, the one or more gesture recognizers in the first software application exclusively receive the second subsequent portion of one or more touch inputs. In addition, the second software application may not receive the second portion of one or more touch inputs during the second phase, because no gesture recognizer in the second software application matches the first portion of one or more touch inputs.

In some embodiments, processing the sequence of touch inputs with the gesture handler corresponding to the respective matching gesture recognizer includes (**834**) displaying in a first predefined area of the touch-sensitive display a group of open application icons that correspond to at least some of a

plurality of concurrently open applications, and concurrently displaying at least a subset of the one or more views of the second software application. For example, in FIG. **7**H, application icons **5004** in predefined area **716** corresponds to concurrently open applications of the electronic device. In some embodiments, application icons **5004** in predefined area **716** are displayed in accordance with a sequence of open applications. In FIG. **7**H, the electronic device concurrently displays predefined area **716** and a subset of web browser application view **712-6**.

In some embodiments, processing the sequence of touch inputs with the gesture handler corresponding to the respective matching gesture recognizer includes (**828**) displaying one or more views of the first software application. For example, in response to a multi-finger pinch gesture (FIG. **7**R), the electronic device displays home screen **708** (FIG. **7**A). In some embodiments, displaying the one or more views of the first software application includes displaying the one or more views of the first software application without concurrently displaying a view corresponding to any other software application (e.g., FIG. **7**A).

In some embodiments, processing the sequence of touch inputs with the gesture handler corresponding to the respective matching gesture recognizer includes (**830**) replacing the display of the one or more views of the second software application with display of one or more views of the first software application (e.g., displaying home screen **708**, FIG. **7**A). Thus, the one or more views of the second software application ceases to be displayed after the one or more views of the first software application are displayed. In some embodiments, replacing the display of the one or more views of the second software application with display of one or more views of the first software application includes displaying the one or more views of the first software application without concurrently displaying a view corresponding to any other software application (FIG. **7**A).

In some embodiments, the electronic device concurrently executes (**832**) the first software application, the second software application, and a third software application. In some embodiments, processing the sequence of touch inputs with the gesture handler corresponding to the respective matching gesture recognizer includes replacing the one or more displayed views of the second software application with one or more views of the third software application. For example, in response to a multi-finger swipe gesture, the electronic device replaces the display of web browser application view **712-6** with a display of weather application view **712-5** (FIGS. **7**J-**7**K). In some embodiments, replacing the one or more displayed views of the second software application with one or more views of the third software application includes displaying the one or more views of the third software application without concurrently displaying a view corresponding to any other software application. In some embodiments, the third software application is next to the second software application in the sequence of open applications.

In some embodiments, processing the sequence of touch inputs with the gesture handler corresponding to the respective matching gesture recognizer includes launching a settings application. For example, in response to a ten-finger tap gesture, the electronic device launches the settings application.

Note that details of the processes described above with respect to method **800** are also applicable in an analogous manner to method **900** described below. For brevity, these details are not repeated below.

FIGS. **9**A-**9**C are flow diagrams illustrating event recognition method **900** in accordance with some embodiments. Method **900** is performed (**902**) at an electronic device with a touch-sensitive display. The electronic device is configured to execute at least a first software application and a second software application. The first software application includes a first set of one or more gesture recognizers, and the second software application includes one or more views and a second set of one or more gesture recognizers. Respective gesture recognizers have corresponding gesture handlers. In some embodiments, the first set of one or more gesture recognizers is different from the second set of one or more gesture recognizers.

Method **900** allows a user to control with a gesture a hidden open application that is not currently displayed on a display of the electronic device (e.g., the first software application), such as a background application, a suspended application, or a hibernated application Thus, the user can perform operations that are not provided by the application currently displayed on the display of the electronic device (e.g., the second software application) but are provided by one of the currently open applications (e.g., displaying a home screen or switching to a next software application using gestures for a hidden application launcher software application).

In some embodiments, the first software application is (**904**) an application launcher (e.g., a springboard). In some embodiments, the first software application is (**906**) an operating system application. In the following description of method **900**, an application launcher is used as an exemplary first software application and a web browser application is used as an exemplary second software application.

The electronic device displays (**908**) a first set of one or more views (e.g., web browser application view **712-6**, FIG. **7**G). The first set of one or more views includes at least a subset of the one or more views of the second software application. For example, the second software application may have a plurality of application views (e.g., application views **317** of application **133-1**, FIG. **3**D), and the electronic device displays at least one view of the plurality of application views. In some embodiments, the subset includes the entire one or more views of the second software application.

In some embodiments, displaying the first set of one or more views includes (**910**) displaying the first set of one or more views without displaying any view of the first software application (e.g., web browser application view **712-6**, FIG. **7**G).

In some embodiments, displaying the first set of one or more views includes (**912**) displaying the first set of one or more views without displaying a view of any other software application. For example, in FIG. **7**G, only one or more views of the web browser application are displayed.

While displaying the first set of the one or more views, the electronic device detects (**914**) a sequence of touch inputs on the touch-sensitive display, and determines (**920**) whether at least one gesture recognizer in the first set of one or more gesture recognizers recognizes the first portion of one or more touch inputs. For example, while displaying web browser application view **712-6** (FIG. **7**G), the device determines whether gesture recognizers for the application launcher recognizes the first portion of the touch inputs. The sequence of touch inputs includes a first portion of one or more touch inputs and a second portion of one or more touch inputs subsequent to the first portion (i.e., the second portion is after the first portion).

In some embodiments, the sequence of touch inputs at least partially overlaps (**916**) at least one of the one or more displayed views of the second software application. For example, the application launcher receives the first portion of

touch inputs on web browser application view **712-6** (FIG. **7**G), even though the application launcher is not displayed.

In some embodiments, prior to a determination that at least one gesture recognizer in the first set of one or more gesture recognizers recognizes the first portion of one or more touch inputs, the electronic device concurrently delivers (**918**) the first portion of one or more touch inputs to the first software application and the second software application. For example, both the application launcher and the web browser application receive the touch-down event of finger contacts **707**, **709**, and **711** (FIG. **7**G) prior to a determination that at least one gesture recognizer in the application launcher recognizes the touch-down event.

In accordance with a determination that at least one gesture recognizer in the first set of one or more gesture recognizers recognizes the first portion of one or more touch inputs (**922**, FIG. **9**B), the electronic device delivers (**924**) the sequence of touch inputs to the first software application without delivering the sequence of touch inputs to the second software application, determines (**926**) whether at least one gesture recognizer in the first set of one or more gesture recognizers recognizes the sequence of touch inputs, and in accordance with a determination that at least one gesture recognizer in the first set of one or more gesture recognizers recognizes the sequence of touch inputs, processes (**928**) the sequence of touch inputs with the at least one gesture recognizer in the first set of one or more gesture recognizers that recognizes the sequence of touch inputs.

For example, when the touch-down and touch-movement of three finger contacts **707**, **709**, and **711** are detected on touch screen **156** (FIG. **7**G), the electronic device identifies that at least a three-finger swipe-up gesture recognizer of the application launcher recognizes the touch inputs. Thereafter, the electronic device delivers subsequent touch events (e.g., lift-off of finger contact **707**, **709**, and **711**) to the application launcher without delivering the subsequent touch events to the web browser application. The electronic device further identifies that the three-finger swipe-up gesture recognizer recognizes the sequence of touch inputs, and processes the sequence of touch inputs with a gesture handler corresponding to the three-finger swipe-up gesture recognizer.

In some embodiments, processing the sequence of touch inputs with the at least one gesture recognizer in the first set of one or more gesture recognizers includes (**930**) displaying one or more views of the first software application. For example, in response to detecting a multi-finger pinch gesture (FIG. **7**R), the electronic device displays home screen **708** (FIG. **7**A).

In some embodiments, processing the sequence of touch inputs with the at least one gesture recognizer in the first set of one or more gesture recognizers includes (**932**) replacing the display of the first set of one or more views with display of one or more views of the first software application (e.g., displaying home screen **708**, FIG. **7**A, which is part of the application launcher software application).

In some embodiments, the electronic device concurrently executes the first software application, the second software application, and a third software application; and processing the sequence of touch inputs with the at least one gesture recognizer in the first set of one or more gesture recognizers includes (**934**) replacing the first set of one or more views with one or more views of the third software application. In some embodiments, replacing the first set of one or more views with one or more views of the third software application includes displaying the one or more views of the third software application without concurrently displaying a view corresponding to any other software application. For example, in response to a multi-finger swipe gesture, the electronic device replaces the display of web browser application view **712-6** with a display of weather application view **712-5** (FIGS. **7**J-**7**K).

In some embodiments, processing the sequence of touch inputs with the at least one gesture recognizer in the first set of one or more gesture recognizers includes (**936**) displaying in a first predefined area of the touch-sensitive display a group of open application icons that correspond to at least some of a plurality of concurrently open applications, and concurrently displaying at least a subset of the first set of one or more views. For example, in FIG. **7**H, application icons **5004** in predefined area **716** corresponds to concurrently open applications of the electronic device. In some embodiments, application icons **5004** in predefined area **716** are displayed in accordance with a sequence of open applications. In FIG. **7**H, the electronic device concurrently displays predefined area **716** and a subset of web browser application view **712-6**.

In accordance with a determination that no gesture recognizer in the first set of one or more gesture recognizers recognizes the first portion of one or more touch inputs (**938**, FIG. **9**C), the electronic device delivers (**940**) the sequence of touch inputs to the second software application, determines (**942**) whether at least one gesture recognizer in the second set of one or more gesture recognizers recognizes the sequence of touch inputs, and in accordance with a determination that at least one gesture recognizer in the second set of one or more gesture recognizers recognizes the sequence of touch inputs, processes (**944**) the sequence of touch inputs with the at least one gesture recognizer in the second set of one or more gesture recognizers that recognizes the sequence of touch inputs.

For example, when the first portion of one or more touch inputs is tap gesture (e.g., **703**, FIG. **7**G), and no gesture recognizer in the application launcher recognizes the tap gesture, the electronic device delivers the tap gesture to the web browser application, and determines whether at least one gesture recognizer of the web browser application recognizes the tap gesture. When the web browser application (or a gesture recognizer of the web browser application) recognizes tap gesture **703** on the bookmark icon, the electronic device processes tap gesture **703** with a corresponding gesture handler.

FIGS. **10**A-**10**B are flow diagrams illustrating an event recognition method in accordance with some embodiments. Note that details of the processes described above with respect to methods **600**, **800**, and **900** are also applicable in an analogous manner to method **1000** described below. For brevity, these details are not repeated below.

Method **1000** is performed (**1002**) at an electronic device with an internal state (e.g., device/global internal state **134**, FIG. **1**C). The electronic device is configured to execute software that includes a view hierarchy with a plurality of views.

In method **1000**, at least one gesture recognizer has a plurality of gesture definitions. This helps the gesture recognizer work in different distinct operating modes. For example, a device may have a normal operating mode and an accessibility operating mode. In the normal operating mode, a next application gesture is used to move between applications, and the next application gesture is defined as a three-finger left-swipe gesture. In the accessibility operating mode, the three-finger left-swipe gesture is used to perform a different function. Thus, a gesture different from the three-finger left-swipe is needed in the accessibility operating mode to correspond to the next application gesture (e.g., a four-finger left-swipe gesture in the accessibility operating mode). By

having multiple gesture definitions associated with the next application gesture, the device can select one of the gesture definitions for the next application gesture, depending on the current operating mode. This provides flexibility in using the gesture recognizer in different operating modes. In some embodiments, a plurality of gesture recognizers with multiple gesture definitions is adjusted depending on the operating mode (e.g., gestures performed with three fingers in the normal operating mode are performed with four fingers in the accessibility operating mode).

In some embodiments, the internal state includes (**1016**) one or more settings for an accessibility operating mode (e.g., the internal state indicates whether the device is operating in the accessibility operating mode).

In some embodiments, the software is (**1018**) or includes an application launcher (e.g., a springboard).

In some embodiments, the software is (**1020**) or includes an operating system application (e.g., an application integrated with an operating system of the device).

The electronic device displays (**1004**) one or more views of the view hierarchy.

The electronic device executes (**1006**) one or more software elements. Each software element is associated with a particular view (e.g., application **133-1** has one or more application views **317**, FIG. **3**D), and each particular view includes one or more event recognizers (e.g., event recognizers **325**, FIG. **3**D). Each event recognizer has one or more event definitions based on one or more sub-events, and an event handler (e.g., gesture definitions **3035** and a reference to a corresponding event handler in event delivery information **3039**, FIG. **3**D). The event handler specifies an action for a target, and is configured to send the action to the target in response to the event recognizer detecting an event corresponding to a particular event definition of the one or more event definitions (e.g., an event definition selected from the one or more event definitions when the event recognizer has multiple event definitions, or a sole event definition when the event recognizer has only one event definition).

The electronic device detects (**1008**) a sequence of one or more sub-events.

The electronic device identifies (**1010**) one of the views of the view hierarchy as a hit view. The hit view establishes which views in the view hierarchy are actively involved views.

The electronic device delivers (**1012**) a respective sub-event to event recognizers for each actively involved view within the view hierarchy. In some embodiments, the one or more actively involved views in the view hierarchy include the hit view. In some embodiments, the one or more actively involved views in the view hierarchy include a default view (e.g., home screen **708** of the application launcher).

At least one event recognizer for actively involved views in the view hierarchy has (**1014**) a plurality of event definitions, one of which is selected in accordance with the internal state of the electronic device. For example, event recognizer **325-1** has a plurality of gesture definitions (e.g., **3037-1** and **3037-2**, FIG. **3**D). In some embodiments, event recognizer **325-1** selects one of the plurality of gesture definitions in event recognizer **325-1** based on one or more values in device/global internal state **134** (FIG. **1**C). The at least one event recognizer then processes the respective sub-event prior to processing a next sub-event in the sequence of sub-events in accordance with the selected event definition. In some embodiments, each of two or more event recognizers for actively involved views in the view hierarchy has a plurality of event definitions, one of which is selected in accordance with the internal state of the electronic device. In such embodiments, at least one of the two or more event recognizers processes the respective sub-event prior to processing the next sub-event in the sequence of sub-events in accordance with the selected event definition.

For example, FIGS. **7**J-**7**K illustrate a next-application gesture that initiates displaying an application view of a next application. In some embodiments, the application launcher includes a next-application gesture recognizer, which includes a gesture definition that matches a three-finger left-swipe gesture. For purposes of this example, assume that the next-application gesture recognizer also includes a gesture definition that corresponds to a four-finger left-swipe gesture. When one or more values in device/global internal state **134** are set to default value(s), the next-application gesture recognizer uses the three-finger left-swipe gesture definition and does not use the four-finger left-swipe gesture definition. When the one or more values in device/global internal state **134** are modified (e.g., by using accessibility module **127**, FIG. **1**C), the next-application gesture recognizer uses the four-finger left-swipe gesture definition and does not use the three-finger left-swipe gesture definition. Thus, in this example, when the one or more values in device/global internal state **134** are modified, a four-finger left-swipe gesture initiates displaying an application view of a next application.

Similarly, FIGS. **7**R-**7**S illustrate that a home screen gesture initiates displaying web browser application view **712-6** at a reduced scale and displaying at least a portion of home screen **708** in response to detecting a five-finger pinch gesture. Based on device/global internal state **134** and gesture definitions in a home screen gesture recognizer, a four-finger pinch gesture, a three-finger pinch gesture, or any other suitable gesture may be used to initiate displaying web-browser application view **712-6** at a reduced scale and displaying at least a portion of home screen **708**.

In some embodiments, the plurality of event definitions includes (**1020**) a first event definition corresponding to a first swipe gesture with a first number of fingers and a second event definition corresponding to a second swipe gesture with a second number of fingers distinct from the first number of fingers. For example, the plurality of event definitions for a respective gesture recognizer may include a three-finger swipe gesture and a four-finger swipe gesture.

In some embodiments, the plurality of event definitions includes a first event definition corresponding a first gesture of a first kind with a first number of fingers and a second event definition corresponding to a second gesture of the first kind with a second number of fingers distinct from the first number of fingers (e.g., a one-finger tap gesture and a two-finger tap gesture, a two-finger pinch gesture and a three-finger pinch gesture, etc.).

In some embodiments, the plurality of event definitions includes a first event definition corresponding to a first gesture and a second event definition corresponding to a second gesture distinct from the first gesture (e.g., a swipe gesture and a pinch gesture, a swipe gesture and a tap gesture, etc.).

In some embodiments, a respective definition of the plurality of event definitions is selected (**1022**) for a respective event recognizer in accordance with the internal state of the electronic device and a determination (by the electronic device) that the respective event definition does not correspond to an event definition of any event recognizer for the actively involved views other than the respective event recognizer.

For example, a respective gesture recognizer may have two event definitions: a first event definition corresponding to a three-finger left swipe gesture that is typically used for a normal operating mode and a second event definition corre-

sponding to a four-finger left swipe gesture that is typically used for an accessibility operating mode. When the internal state of the electronic device is set in a way such that the electronic device operates in the accessibility mode, the electronic device determines whether the four-finger left swipe gesture for the second event definition is used by any other event recognizer for the actively involved views. If the four-finger left swipe gesture is not used by any other event recognizer for the actively involved views, the four-finger left swipe gesture is selected for the respective gesture recognizer in the accessibility operating mode. On the other hand, if the four-finger left swipe gesture is used by any other event recognizer for the actively involved views, the three-finger left swipe gesture is used for the respective gesture recognizer even in the accessibility operating mode. This prevents two or more gesture recognizers from undesirably responding to a same gesture.

In some embodiments, a respective definition of the plurality of event definitions is selected for a respective event recognizer in accordance with the internal state of the electronic device and a determination (by the electronic device) that the respective event definition does not correspond to an event definition of any event recognizer (including event recognizers for the actively involved views and any other views) other than the respective event recognizer.

In some embodiments, two or more event recognizers for actively involved views in the view hierarchy each have (**1024**) a respective plurality of event definitions, and a respective event definition of the respective plurality of event definitions is selected for a respective event recognizer in accordance with the internal state of the electronic device and a determination (by the electronic device) that the respective event definition does not correspond to any event definition selected for any event recognizer with two or more event definitions other than the respective event recognizer.

For example, actively involved views may have a first gesture recognizer and a second gesture recognizer. In this example, the first gesture recognizer has: a first event definition corresponding to a three-finger left swipe gesture that is typically used for a normal operating mode and a second event definition corresponding to a four-finger left swipe gesture that is typically used for an accessibility operating mode. The second gesture recognizer has: a third event definition corresponding to a two-finger left swipe gesture that is typically used for the normal operating mode and a fourth event definition corresponding to the four-finger left swipe gesture that is typically used for the accessibility operating mode. When the internal state of the electronic device is set in a way such that the electronic device operates in the accessibility mode, the electronic device determines whether a four-finger left swipe gesture that satisfies the second event definition is selected for any other event recognizer with two or more event definitions (e.g., the second event gesture recognizer). If the four-finger left swipe gesture is not selected for any other event recognizer with two or more event definitions, the four-finger left swipe gesture is selected for the first gesture recognizer in the accessibility operating mode. As a result, the four-finger left swipe gesture is not selected for the second gesture recognizer, because the four-finger left swipe gesture is already selected for the first gesture recognizer. Instead, the two-finger left swipe gesture is selected for the second gesture recognizer, because the two-finger left swipe gesture is not selected for any other gesture recognizer with two or more event definitions including the first gesture recognizer. In another example, the actively involved views have the first gesture recognizer and a third gesture recognizer without the second gesture recognizer. The third gesture recognizer has the third event definition (corresponding to the two-finger left swipe gesture) that is typically used for the normal operating mode and a fifth event definition corresponding to a three-finger left swipe gesture that is typically used for the accessibility operating mode. In the accessibility operating mode, the three-finger left swipe gesture can be selected for the third gesture recognizer, because the three-finger left swipe gesture is not selected for any other gesture recognizer with two or more event definitions.

Although the examples above have been described with respect to multi-finger left swipe gestures, the methods described above apply to swipe gestures in any direction (e.g., a swipe-right gesture, swipe-up gesture, swipe-down gesture, and/or any diagonal swipe gesture) or gestures of any other kinds (e.g., tap gestures, pinch gestures, depinch gestures, etc.).

In some embodiments, processing the respective sub-event in accordance with the selected event definition includes (**1026**) displaying one or more views of a first software application distinct from the software that includes the view hierarchy (e.g., concurrently displaying at least a portion of user interface **712-6** including one or more views of the software and a portion of home screen **708**, FIG. **7**S).

In some embodiments, the at least one event recognizer processes (**1028**) the respective sub-event by replacing the display of the one or more views of the view hierarchy with display of one or more views of a first software application (e.g., home screen **708**, FIG. **7**A) distinct from the software that includes the view hierarchy.

In some embodiments, the at least one event recognizer processes (**1030**) the respective sub-event by: displaying in a first predefined area of a display in the electronic device a group of open application icons that correspond to at least some of a plurality of concurrently open applications; and concurrently displaying at least a subset of the one or more views of the view hierarchy (e.g., open application icons **5004** and at least a portion of user interface **712-6**, FIG. **7**H). For example, the electronic device concurrently displays the group of open application icons and at least a subset of the one or more views of the view hierarchy in response to a three-finger swipe-up gesture in the normal operating mode and a four-finger swipe-up gesture in the accessibility operating mode.

In accordance with some embodiments, FIG. **11** shows a functional block diagram of an electronic device **1100** configured in accordance with the principles of the invention as described above. The functional blocks of the device may be implemented by hardware, software, or a combination of hardware and software to carry out the principles of the invention. It is understood by persons of skill in the art that the functional blocks described in FIG. **11** may be combined or separated into sub-blocks to implement the principles of the invention as described above. Therefore, the description herein may support any possible combination or separation or further definition of the functional blocks described herein.

As shown in FIG. **11**, an electronic device **1100** includes a touch-sensitive display unit **1102** configured to receive touch inputs; and a processing unit **1106** coupled to the touch-sensitive display unit **1102**. In some embodiments, the processing unit **1106** includes an executing unit **1108**, a display enabling unit **1110**, a detecting unit **1112**, a delivering unit **1114**, an identifying unit **1116**, and a touch input processing unit **1118**.

The processing unit **1106** is configured to: execute at least a first software application and a second software application (e.g., with the executing unit **1108**). The first software application includes a first set of one or more gesture recognizers,

and the second software application includes one or more views and a second set of one or more gesture recognizers. Respective gesture recognizers have corresponding gesture handlers. The processing unit **1106** is configured to enable display of at least a subset of the one or more views of the second software application (e.g., with the display enabling unit **1110**, on the touch-sensitive display unit **1102**). The processing unit **1106** is configured to, while displaying at least the subset of the one or more views of the second software application: detect a sequence of touch inputs on the touch-sensitive display unit **1102** (e.g., with the detecting unit **1112**). The sequence of touch inputs includes a first portion of one or more touch inputs and a second portion of one or more touch inputs subsequent to the first portion. The processing unit **1106** is configured to, during a first phase of detecting the sequence of touch inputs: deliver the first portion of one or more touch inputs to the first software application and the second software application (e.g., with the delivering unit **1114**); identify from gesture recognizers in the first set one or more matching gesture recognizers that recognize the first portion of one or more touch inputs (e.g., with the identifying unit **1116**); and process the first portion of one or more touch inputs with one or more gesture handlers corresponding to the one or more matching gesture recognizers (e.g., with the touch input processing unit **1118**).

In some embodiments, the processing unit **1106** is configured to detect the sequence of touch inputs (e.g., with the detecting unit **1112**) while touch inputs in the first portion of one or more touch inputs at least partially overlap at least one of the displayed views of the second software application.

In some embodiments, the processing unit **1106** is configured to enable display of at least a subset of the one or more views of the second software application without displaying any view of the first software application (e.g., with the display enabling unit **1110**, on the touch-sensitive display unit **1102**).

In some embodiments, the processing unit **1106** is configured to enable display of at least a subset of the one or more views of the second software application without displaying a view of any other application (e.g., with the display enabling unit **1110**, on the touch-sensitive display unit **1102**).

In some embodiments, the processing unit **1106** is configured to, during a second phase of detecting the sequence of touch inputs, subsequent to the first phase: deliver the second portion of one or more touch inputs to the first software application without delivering the second portion of one or more touch inputs to the second software application (e.g., with the delivering unit **1114**); identify from the one or more matching gesture recognizers a second matching gesture recognizer that recognizes the sequence of touch inputs (e.g., with the identifying unit **1116**); and process the sequence of touch inputs with a gesture handler corresponding to the respective matching gesture recognizer (e.g., with the touch input processing unit **1118**).

In some embodiments, the processing unit **1106** is configured to process the sequence of touch inputs with the gesture handler corresponding to the respective matching gesture recognizer by enabling display of one or more views of the first software application (e.g., with the display enabling unit **1110**, on the touch-sensitive display unit **1102**).

In some embodiments, the processing unit **1106** is configured to process the sequence of touch inputs with the gesture handler corresponding to the respective matching gesture recognizer by replacing the display of the one or more views of the second software application with display of one or more views of the first software application (e.g., with the display enabling unit **1110**, on the touch-sensitive display unit **1102**).

In some embodiments, the processing unit **1106** is configured to: concurrently execute the first software application, the second software application, and a third software application (e.g., with the executing unit **1108**); and process the sequence of touch inputs with the gesture handler corresponding to the respective matching gesture recognizer by replacing the one or more displayed views of the second software application with one or more views of the third software application (e.g., with the display enabling unit **1110**, on the touch-sensitive display unit **1102**).

In some embodiments, the processing unit **1106** is configured to: enable display of, in a first predefined area of the touch-sensitive display unit **1102**, a group of open application icons that correspond to at least some of a plurality of concurrently open applications (e.g., with the display enabling unit **1110**); and enable concurrent display of at least a subset of the one or more views of the second software application (e.g., with the display enabling unit **1110**).

In some embodiments, the first software application is an application launcher.

In some embodiments, the first software application is an operating system application.

In accordance with some embodiments, FIG. **12** shows a functional block diagram of an electronic device **1200** configured in accordance with the principles of the invention as described above. The functional blocks of the device may be implemented by hardware, software, or a combination of hardware and software to carry out the principles of the invention. It is understood by persons of skill in the art that the functional blocks described in FIG. **12** may be combined or separated into sub-blocks to implement the principles of the invention as described above. Therefore, the description herein may support any possible combination or separation or further definition of the functional blocks described herein.

As shown in FIG. **12**, an electronic device **1200** includes a touch-sensitive display unit **1202** configured to receive touch inputs; and a processing unit **1206** coupled to the touch-sensitive display unit **1202**. In some embodiments, the processing unit **1206** includes an executing unit **1208**, a display enabling unit **1210**, a detecting unit **1212**, a determining unit **1214**, a delivering unit **1216**, and a touch input processing unit **1218**.

The processing unit **1206** is configured to execute at least a first software application and a second software application (e.g., with the executing unit **1208**). The first software application includes a first set of one or more gesture recognizers, and the second software application includes one or more views and a second set of one or more gesture recognizers. Respective gesture recognizers have corresponding gesture handlers. The processing unit **1206** is configured to enable display of a first set of one or more views (e.g., with the display enabling unit **1210**). The first set of one or more views include at least a subset of the one or more views of the second software application. The processing unit **1206** is configured to, while displaying the first set of the one or more views, detect a sequence of touch inputs on the touch-sensitive display unit (e.g., with the detecting unit **1212**). The sequence of touch inputs includes a first portion of one or more touch inputs and a second portion of one or more touch inputs subsequent to the first portion. The processing unit **1206** is configured to determine whether at least one gesture recognizer in the first set of one or more gesture recognizers recognizes the first portion of one or more touch inputs (e.g., with the determining unit **1214**). The processing unit **1206** is

configured to, in accordance with a determination that at least one gesture recognizer in the first set of one or more gesture recognizers recognizes the first portion of one or more touch inputs: deliver the sequence of touch inputs to the first software application without delivering the sequence of touch inputs to the second software application (e.g., with the delivering unit **1216**); determine whether at least one gesture recognizer in the first set of one or more gesture recognizers recognizes the sequence of touch inputs (e.g., with the determining unit **1214**). The processing unit **1206** is configured to, in accordance with a determination that at least one gesture recognizer in the first set of one or more gesture recognizers recognizes the sequence of touch inputs, process the sequence of touch inputs with the at least one gesture recognizer in the first set of one or more gesture recognizers that recognizes the sequence of touch inputs (e.g., with the touch input processing unit **1218**). The processing unit **1206** is configured to, in accordance with a determination that no gesture recognizer in the first set of one or more gesture recognizers recognizes the first portion of one or more touch inputs: deliver the sequence of touch inputs to the second software application (e.g., with the delivering unit **1216**); and determine whether at least one gesture recognizer in the second set of one or more gesture recognizers recognizes the sequence of touch inputs (e.g., with the determining unit **1214**). The processing unit **1206** is configured to, in accordance with a determination that at least one gesture recognizer in the second set of one or more gesture recognizers recognizes the sequence of touch inputs, process the sequence of touch inputs with the at least one gesture recognizer in the second set of one or more gesture recognizers that recognizes the sequence of touch inputs (e.g., with the touch input processing unit **1218**).

In some embodiments, the sequence of touch inputs at least partially overlaps at least one of the one or more displayed views of the second software application.

In some embodiments, the processing unit **1206** is configured to enable display of the first set of one or more views without displaying any view of the first software application (e.g., with the display enabling unit **1210**, on the touch-sensitive display unit **1202**).

In some embodiments, the processing unit **1206** is configured to enable display of the first set of one or more views without displaying a view of any other software application (e.g., with the display enabling unit **1210**, on the touch-sensitive display unit **1202**).

In some embodiments, prior to the determination that at least one gesture recognizer in the first set of one or more gesture recognizers recognizes the first portion of one or more touch inputs, the processing unit **1206** is configured to concurrently deliver the first portion of one or more touch inputs to the first software application and the second software application (e.g., with the delivering unit **1216**).

In some embodiments, the first software application is an application launcher.

In some embodiments, the first software application is an operating system application.

In some embodiments, the processing unit **1206** is configured to process the sequence of touch inputs with the at least one gesture recognizer in the first set of one or more gesture recognizers by enabling displaying one or more views of the first software application (e.g., with the display enabling unit **1208**, on the touch-sensitive display unit **1202**).

In some embodiments, the processing unit **1206** is configured to process the sequence of touch inputs with the at least one gesture recognizer in the first set of one or more gesture recognizers by replacing the display of the first set of one or more views with display of one or more views of the first software application (e.g., with the display enabling unit **1208**, on the touch-sensitive display unit **1202**).

In some embodiments, the processing unit **1206** is configured to concurrently execute the first software application, the second software application, and a third software application (e.g., with the executing unit **1208**). The processing unit **1206** is configured to process the sequence of touch inputs with the at least one gesture recognizer in the first set of one or more gesture recognizers by replacing the first set of one or more views with one or more views of the third software application (e.g., with the display enabling unit **1210**, on the touch-sensitive display unit **1202**).

In some embodiments, the processing unit **1206** is configured to: enable display of in a first predefined area of the touch-sensitive display unit **1202** a group of open application icons that correspond to at least some of a plurality of concurrently open applications (e.g., with the display enabling unit **1210**); and concurrently display at least a subset of the first set of one or more views (e.g., with the display enabling unit **1210**).

In accordance with some embodiments, FIG. **13** shows a functional block diagram of an electronic device **1300** configured in accordance with the principles of the invention as described above. The functional blocks of the device may be implemented by hardware, software, or a combination of hardware and software to carry out the principles of the invention. It is understood by persons of skill in the art that the functional blocks described in FIG. **13** may be combined or separated into sub-blocks to implement the principles of the invention as described above. Therefore, the description herein may support any possible combination or separation or further definition of the functional blocks described herein.

As shown in FIG. **13**, an electronic device **1300** includes a display unit **1302** configured to display one or more views; a memory unit **1304** configured to store an internal state; and a processing unit **1306** coupled to the display unit **1302** and the memory unit **1304**. In some embodiments, the processing unit **1306** includes an executing unit **1308**, a display enabling unit **1310**, a detecting unit **1312**, an identifying unit **1314**, a delivering unit **1316**, and an event/sub-event processing unit **1318**. In some embodiments, the processing unit **1306** includes the memory unit **1304**.

The processing unit **1306** is configured to: execute software that includes a view hierarchy with a plurality of views (e.g., with the executing unit **1308**); enable display of one or more views of the view hierarchy (e.g., with the display enabling unit **1310**, on the display unit **1302**); and execute one or more software elements (e.g., with the executing unit **1308**). Each software element is associated with a particular view, and each particular view includes one or more event recognizers. Each event recognizer has: one or more event definitions based on one or more sub-events, and an event handler. The event handler specifies an action for a target, and is configured to send the action to the target in response to the event recognizer detecting an event corresponding to a particular event definition of the one or more event definitions. The processing unit **1306** is configured to: detect a sequence of one or more sub-events (e.g., with the detecting unit **1312**); and identify one of the views of the view hierarchy as a hit view (e.g., with the identifying unit **1314**). The hit view establishes which views in the view hierarchy are actively involved views. The processing unit **1306** is configured to deliver a respective sub-event to event recognizers for each actively involved view within the view hierarchy (e.g., with the delivering unit **1316**). At least one event recognizer for actively involved views in the view hierarchy has a plurality of event definitions, one of which is selected in accordance

with the internal state of the electronic device, and the at least one event recognizer processes the respective sub-event (e.g., with the event/sub-event processing unit **1318**) prior to processing a next sub-event in the sequence of sub-events in accordance with the selected event definition.

In some embodiments, the plurality of event definitions includes a first event definition corresponding to a first swipe gesture with a first number of fingers and a second event definition corresponding to a second swipe gesture with a second number of fingers distinct from the first number of fingers.

In some embodiments, the internal state includes one or more settings for an accessibility operating mode.

In some embodiments, a respective definition of the plurality of event definitions is selected for a respective event recognizer in accordance with the internal state of the electronic device and a determination that the respective event definition does not correspond to an event definition of any event recognizer for the actively involved views other than the respective event recognizer.

In some embodiments, two or more event recognizers for actively involved views in the view hierarchy each have a respective plurality of event definitions, and a respective event definition of the respective plurality of event definitions is selected for a respective event recognizer in accordance with the internal state of the electronic device and a determination that the respective event definition does not correspond to any event definition selected for any event recognizer with two or more event definitions other than the respective event recognizer.

In some embodiments, the processing unit **1306** is configured to process the respective sub-event in accordance with the selected event definition by enabling display of one or more views of a first software application distinct from the software that includes the view hierarchy (e.g., with the display enabling unit **1310**, on the display unit **1302**).

In some embodiments, the processing unit **1306** is configured to process the respective sub-event by replacing the display of the one or more views of the view hierarchy with display of one or more views of a first software application distinct from the software that includes the view hierarchy (e.g., with the display enabling unit **1310**, on the display unit **1302**).

In some embodiments, the processing unit **1306** is configured to process the respective sub-event by: enabling display of, in a first predefined area of the display unit **1302**, a group of open application icons that correspond to at least some of a plurality of concurrently open applications (e.g., with the display enabling unit **1310**); and enabling concurrently display of at least a subset of the one or more views of the view hierarchy (e.g., with the display enabling unit **1310**).

In some embodiments, the software is an application launcher.

In some embodiments, the software is an operating system application.

The foregoing description, for purpose of explanation, has been described with reference to specific embodiments. However, the illustrative discussions above are not intended to be exhaustive or to limit the invention to the precise forms disclosed. Many modifications and variations are possible in view of the above teachings. The embodiments were chosen and described in order to best explain the principles of the invention and its practical applications, to thereby enable others skilled in the art to best utilize the invention and various embodiments with various modifications as are suited to the particular use contemplated.

What is claimed is:

**1**. A method, comprising:

at an electronic device with an internal state, the electronic device configured to execute software that includes a view hierarchy with a plurality of views:

displaying one or more views of the view hierarchy;

executing one or more software elements, each software element being associated with a particular view that includes one or more event recognizers, each event recognizer having:

one or more event definitions based on one or more sub-events, and

an event handler, wherein the event handler:

specifies an action for a target, and

is configured to send the action to the target in response to the event recognizer detecting an event corresponding to a particular event definition of the one or more event definitions;

detecting a sequence of one or more sub-events;

identifying a respective view of the view hierarchy as a hit view, wherein the hit view establishes which views in the view hierarchy are actively involved views; and

delivering a respective sub-event to an event recognizer for the respective view, wherein the respective view has a plurality of event definitions for a respective event, one of which is selected in accordance with the internal state of the electronic device, and the respective event recognizer processes the respective sub-event prior to processing a next sub-event in the sequence of sub-events in accordance with the selected event definition, including:

sending an action to a respective target in response to the event recognizer detecting an event corresponding to a first event definition of the plurality of event definitions when the first event definition has been selected in accordance with the internal state of the electronic device, and

sending an action to the same respective target in response to the event recognizer detecting an event corresponding to a second event definition, distinct from the first event definition, of the plurality of event definitions when the second event definition has been selected in accordance with the internal state of the electronic device.

**2**. The method of claim **1**, wherein the plurality of event definitions includes a first event definition corresponding to a first swipe gesture with a first number of fingers and a second event definition corresponding to a second swipe gesture with a second number of fingers distinct from the first number of fingers.

**3**. The method of claim **1**, wherein the internal state includes one or more settings for an accessibility operating mode.

**4**. The method of claim **1**, wherein a respective definition of the plurality of event definitions is selected for a respective event recognizer in accordance with the internal state of the electronic device and a determination that the respective event definition does not correspond to an event definition of any event recognizer for the actively involved views other than the respective event recognizer.

**5**. The method of claim **1**, wherein two or more event recognizers for the actively involved views in the view hierarchy each have a respective plurality of event definitions, and a respective event definition of the respective plurality of event definitions is selected for a respective event recognizer in accordance with the internal state of the electronic device and a determination that the respective event definition does

not correspond to any event definition selected for any event recognizer with two or more event definitions other than the respective event recognizer.

**6**. The method of claim **1**, wherein processing the respective sub-event in accordance with the selected event definition includes displaying one or more views of a first software application distinct from the software that includes the view hierarchy.

**7**. The method of claim **1**, wherein the respective event recognizer processes the respective sub-event by replacing the display of the one or more views of the view hierarchy with display of one or more views of a first software application distinct from the software that includes the view hierarchy.

**8**. The method of claim **1**, wherein the respective event recognizer processes the respective sub-event by:

displaying in a first predefined area of a display in the electronic device a group of open application icons that correspond to at least some of a plurality of concurrently open applications; and

concurrently displaying at least a subset of the one or more views of the view hierarchy.

**9**. The method of claim **1**, wherein the software is an application launcher.

**10**. The method of claim **1**, wherein the software is an operating system application.

**11**. The method of claim **1**, wherein:

when a first event definition is selected for a respective event recognizer in accordance with the internal state of the electronic device, the event recognizer is configured to recognize a first sequence of one or more sub-events that corresponds to the first event definition and the event recognizer is not configured to recognize a second sequence of one or more sub-events, distinct from the first sequence of one or more sub-events, that does not correspond to the first event definition; and

when a second event definition, distinct from the first event definition, is selected for the respective event recognizer in accordance with the internal state of the electronic device, the event recognizer is configured to recognize the second sequence of one or more sub-events that corresponds to the second event definition and the event recognizer is not configured to recognize the first sequence of one or more sub-events.

**12**. The method of claim **1**, including:

displaying two or more views of the view hierarchy;

executing two or more software elements, each software element being associated with a particular view, wherein each particular view includes one or more event recognizers of a plurality of distinct event recognizers, each event recognizer of the plurality of distinct event recognizers having:

one or more event definitions based on a sequence of sub-events, and

an event handler, wherein the event handler:

specifies an action for a target, and

is configured to send the action to the target in response to the event recognizer detecting an event corresponding to a particular event definition of the one or more event definitions.

**13**. The method of claim **1**, wherein the internal state of the electronic device is identified prior to detecting any sub-event of the sequence of one or more sub-events.

**14**. An electronic device, comprising:

a display;

one or more processors; and

memory storing an internal state and one or more programs for execution by the one or more processors, the one or more programs including software that includes a view hierarchy with a plurality of views, wherein the one or more programs include instructions for:

displaying one or more views of the view hierarchy;

executing one or more software elements, each software element being associated with a particular view that includes one or more event recognizers, each event recognizer having:

one or more event definitions based on one or more sub-events, and

an event handler, wherein the event handler:

specifies an action for a target, and

is configured to send the action to the target in response to the event recognizer detecting an event corresponding to a particular event definition of the one or more event definitions;

detecting a sequence of one or more sub-events;

identifying a respective view of the view hierarchy as a hit view, wherein the hit view establishes which views in the view hierarchy are actively involved views; and

delivering a respective sub-event to an event recognizer for the respective view, wherein the respective view has a plurality of event definitions for a respective event, one of which is selected in accordance with the internal state of the electronic device, and the respective event recognizer processes the respective sub-event prior to processing a next sub-event in the sequence of sub-events in accordance with the selected event definition, including:

sending an action to a respective target in response to the event recognizer detecting an event corresponding to a first event definition of the plurality of event definitions when the first event definition has been selected in accordance with the internal state of the electronic device, and

sending an action to the same respective target in response to the event recognizer detecting an event corresponding to a second event definition, distinct from the first event definition, of the plurality of event definitions when the second event definition has been selected in accordance with the internal state of the electronic device.

**15**. The electronic device of claim **14**, wherein the plurality of event definitions includes a first event definition corresponding, to a first swipe gesture with a first number of fingers and a second event definition corresponding to a second swipe gesture with a second number of fingers distinct from the first number of fingers.

**16**. The electronic device of claim **14**, wherein a respective definition of the plurality of event definitions is selected for a respective event recognizer in accordance with the internal state of the electronic device and a determination that the respective event definition does not correspond to an event definition of any event recognizer for the actively involved views other than the respective event recognizer.

**17**. The electronic device of claim **14**, wherein two or more event recognizers for the actively involved views in the view hierarchy each have a respective plurality of event definitions, and a respective event definition of the respective plurality of event definitions is selected for a respective event recognizer in accordance with the internal state of the electronic device and a determination that the respective event definition does not correspond to any event definition selected for any event recognizer with two or more event definitions other than the respective event recognizer.

18. The electronic device of claim 14, wherein the instructions for processing the respective sub-event include instructions for replacing the display of the one or more views of the view hierarchy with display of one or more views of a first software application distinct from the software that includes the view hierarchy.

19. The electronic device of claim 14, wherein:

when a first event definition is selected for a respective event recognizer in accordance with the internal state of the electronic device, the event recognizer is configured to recognize a first sequence of one or more sub-events that corresponds to the first event definition and the event recognizer is not configured to recognize a second sequence of one or more sub-events, distinct from the first sequence of one or more sub-events, that does not correspond to the first event definition; and

when a second event definition, distinct from the first event definition, is selected for the respective event recognizer in accordance with the internal state of the electronic device, the event recognizer is configured to recognize the second sequence of one or more sub-events that corresponds to the second event definition and the event recognizer is not configured to recognize the first sequence of one or more sub-events.

20. The electronic device of claim 14, wherein the one or more programs include instructions for:

displaying two or more views of the view hierarchy;

executing two or more software elements, each software element being associated with a particular view, wherein each particular view includes one or more event recognizers of a plurality of distinct event recognizers, each event recognizer of the plurality of distinct event recognizers having:

one or more event definitions based on a sequence of sub-events, and

an event handler, wherein the event handler:

specifies an action for a target, and

is configured to send the action to the target in response to the event recognizer detecting an event corresponding to a particular event definition of the one or more event definitions.

21. A non-transitory computer readable storage medium storing one or more programs for execution by one or more processors in an electronic device that has an internal state, the one or more programs including software that includes a view hierarchy with a plurality of views, wherein the one or more programs include instructions for:

displaying one or more views of the view hierarchy;

executing one or more software elements, each software element being associated with a particular view that includes one or more event recognizers, each event recognizer having:

one or more event definitions based on one or more sub-events, and

an event handler, wherein the event handler:

specifies an action for a target, and

is configured to send the action to the target in response to the event recognizer detecting an event corresponding to a particular event definition of the one or more event definitions;

detecting a sequence of one or more sub-events;

identifying a respective view of the view hierarchy as a hit view, wherein the hit view establishes which views in the view hierarchy are actively involved views; and

delivering a respective sub-event to an event recognizer for the respective view, wherein the respective view has a plurality of event definitions for a respective event, one of which is selected in accordance with the internal state of the electronic device, and the respective event recognizer processes the respective sub-event prior to processing a next sub-event in the sequence of sub-events in accordance with the selected event definition, including:

sending an action to a respective target in response to the event recognizer detecting an event corresponding to a first event definition of the plurality of event definitions when the first event definition has been selected in accordance with the internal state of the electronic device, and

sending an action to the same respective target in response to the event recognizer detecting an event corresponding to a second event definition, distinct from the first event definition, of the plurality of event definitions when the second event definition has been selected in accordance with the internal state of the electronic device.

22. The computer readable storage medium of claim 21, wherein the plurality of event definitions includes a first event definition corresponding to a first swipe gesture with a first number of fingers and a second event definition corresponding to a second swipe gesture with a second number of fingers distinct from the first number of fingers.

23. The computer readable storage medium of claim 21, wherein a respective definition of the plurality of event definitions is selected for a respective event recognizer in accordance with the internal state of the electronic device and a determination that the respective event definition does not correspond to an event definition of any event recognizer for the actively involved views other than the respective event recognizer.

24. The computer readable storage medium of claim 21, wherein two or more event recognizers for the actively involved views in the view hierarchy each have a respective plurality of event definitions, and a respective event definition of the respective plurality of event definitions is selected for a respective event recognizer in accordance with the internal state of the electronic device and a determination that the respective event definition does not correspond to any event definition selected for any event recognizer with two or more event definitions other than the respective event recognizer.

25. The computer readable storage medium of claim 21, wherein the instructions for processing the respective sub-event include instructions for replacing the display of the one or more views of the view hierarchy with display of one or more views of a first software application distinct from the software that includes the view hierarchy.

26. The computer readable storage medium of claim 21, wherein:

when a first event definition is selected for a respective event recognizer in accordance with the internal state of the electronic device, the event recognizer is configured to recognize a first sequence of one or more sub-events that corresponds to the first event definition and the event recognizer is not configured to recognize a second sequence of one or more sub-events, distinct from the first sequence of one or more sub-events, that does not correspond to the first event definition; and

when a second event definition, distinct from the first event definition, is selected for the respective event recognizer in accordance with the internal state of the electronic device, the event recognizer is configured to recognize the second sequence of one or more sub-events that corresponds to the second event definition and the event recognizer is not configured to recognize the first sequence of one or more sub-events.

27. The computer readable storage medium of claim 21, wherein the one or more programs include instructions for:

displaying two or more views of the view hierarchy;

executing two or more software elements, each software element being associated with a particular view, wherein each particular view includes one or more event recognizers of a plurality of distinct event recognizers, each event recognizer of the plurality of distinct event recognizers having:

one or more event definitions based on a sequence of sub-events, and

an event handler, wherein the event handler:

specifies an action for a target, and

is configured to send the action to the target in response to the event recognizer detecting an event corresponding to a particular event definition of the one or more event definitions.

28. A method, comprising:

at an electronic device with an internal state, the electronic device configured to execute software that includes a view hierarchy with a plurality of views:

displaying one or more views of the view hierarchy;

detecting a sequence of sub-events;

delivering a respective sub-event, in the sequence of sub-events, to multiple event recognizers, wherein a respective event recognizer of the multiple event recognizers has a plurality of event definitions for a respective event;

selecting one of the plurality of event definitions of the respective event, for the respective event recognizer, in accordance with the internal state of the electronic device;

processing the sequence of sub-events, with the respective event recognizer, to determine whether the sequence of sub-events matches the selected event definition, including determining whether the sequence of sub-events matches a first event definition of the plurality of event definitions when the first event definition has been selected for the respective event recognizer in accordance with the internal state of the electronic device and determining whether the sequence of sub-events matches a second event definition, distinct from the first event definition, of the plurality of event definitions when the second event definition has been selected for the respective event recognizer in accordance with the internal state of the electronic device; and,

in accordance with a determination that sequence of sub-events matches the selected event definition, activating a respective event handler that corresponds to the respective event recognizer.

29. An electronic device, comprising:

a display;

one or more processors; and

memory storing an internal state and one or more programs for execution by the one or more processors, the one or more programs including instructions for:

displaying one or more views of a view hierarchy, the view hierarchy including a plurality of views;

detecting a sequence of sub-events;

delivering a respective sub-event, in the sequence of sub-events, to multiple event recognizers, wherein a respective event recognizer of the multiple event recognizers has a plurality of event definitions for a respective event;

selecting one of the plurality of event definitions of the respective event, for the respective event recognizer, in accordance with the internal state of the electronic device;

processing the sequence of sub-events, with the respective event recognizer, to determine whether the sequence of sub-events matches the selected event definition, including determining whether the sequence of sub-events matches a first event definition of the plurality of event definitions when the first event definition has been selected for the respective event recognizer in accordance with the internal state of the electronic device and determining whether the sequence of sub-events matches a second event definition, distinct from the first event definition, of the plurality of event definitions when the second event definition has been selected for the respective event recognizer in accordance with the internal state of the electronic device; and,

in accordance with a determination that sequence of sub-events matches the selected event definition, activating a respective event handler that corresponds to the respective event recognizer.

30. A non-transitory computer readable storage medium storing one or more programs for execution by one or more processors in an electronic device that has an internal state, the one or more programs including instructions for:

displaying one or more views of a view hierarchy, the view hierarchy including a plurality of views;

detecting a sequence of sub-events;

delivering a respective sub-event, in the sequence of sub-events, to multiple event recognizers, wherein a respective event recognizer of the multiple event recognizers has a plurality of event definitions for a respective event;

selecting one of the plurality of event definitions of the respective event, for the respective event recognizer, in accordance with the internal state of the electronic device;

processing the sequence of sub-events, with the respective event recognizer, to determine whether the sequence of sub-events matches the selected event definition, including determining whether the sequence of sub-events matches a first event definition of the plurality of event definitions when the first event definition has been selected for the respective event recognizer in accordance with the internal state of the electronic device and determining whether the sequence of sub-events matches a second event definition, distinct from the first event definition, of the plurality of event definitions when the second event definition has been selected for the respective event recognizer in accordance with the internal state of the electronic device; and,

in accordance with a determination that sequence of sub-events matches the selected event definition, activating a respective event handler that corresponds to the respective event recognizer.

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