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VanderDrift

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(45) **Date of Patent: Jul. 19, 2011**

(54) SYSTEM AND METHOD FOR NON-PROGRAMMERS TO DYNAMICALLY MANAGE MULTIPLE SETS OF XML DOCUMENT DATA

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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 188 days.

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Related U.S. Application Data

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G06F 17/30 (2006.01)
G06F 17/00 (2006.01)

(52) **U.S. Cl.** **707/805**; 707/802; 707/803; 707/804

(58) **Field of Classification Search** 707/100–102, 707/1, 2, 3, 802–805; 709/203; 715/241, 715/235; 719/313
See application file for complete search history.

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(57) **ABSTRACT**

A system and method for dynamically retrieving, manipulating, updating, creating, and displaying data from sources of Extensible Markup Language (XML) documents. The program memory comprises system-user entered data definitions and business rules. The system imports XML document data into the system data definitions, processes the data using the business rules definitions and exports XML documents. The system can automatically create XML document formats from its data definitions and can automatically create its data definitions from XML document formats. The system-user can also define the mapping between XML document formats and the system data definitions. The system data definition is the combination of a Relational data model, an Object data model, and an XML data model.

29 Claims, 30 Drawing Sheets

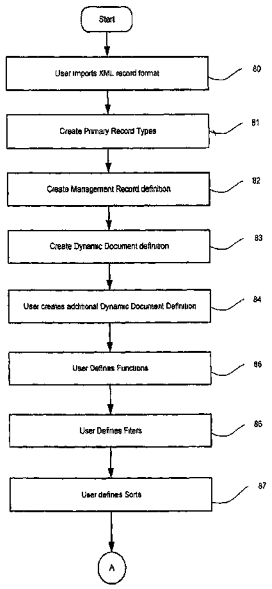
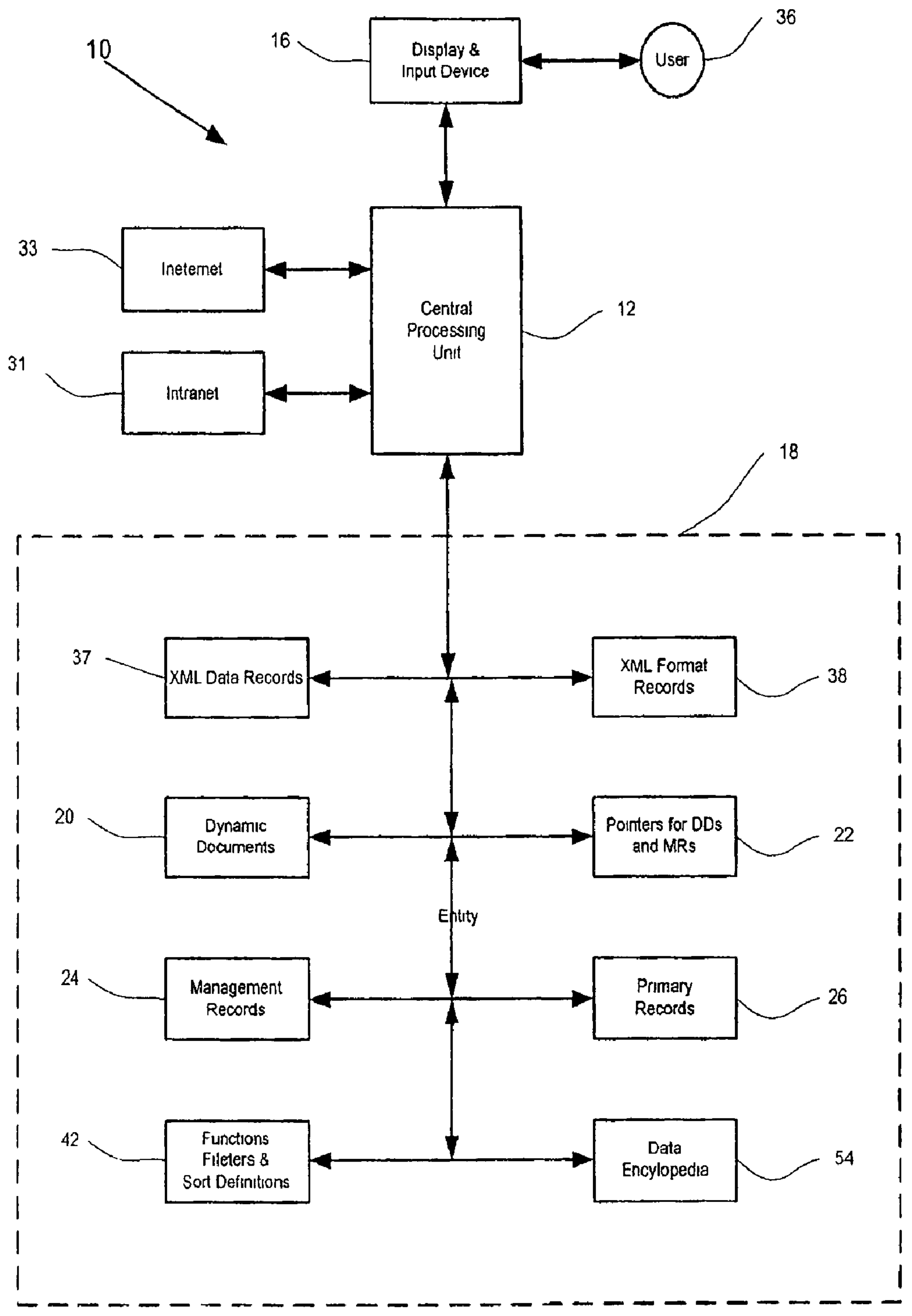

Start
User imports XML record format
80
Create Primary Record Types
81
Create Management Record definition
82
Create Dynamic Document definition
83
User creates additional Dynamic Document Definition
84
User Defines Functions
85
User Defines Filters
86
User defines Sorts
87
A

Figure 1



10
16
Display & Input Device
User
36
33
Inetemet
Central Processing Unit
12
31
Intranet
18
37
XML Data Records
XML Format Records
38
20
Dynamic Documents
Pointers for DDs and MRs
22
Entity
24
Management Records
Primary Records
26
42
Functions Fileters & Sort Definitions
Data Encylopedia
54

Figure 2

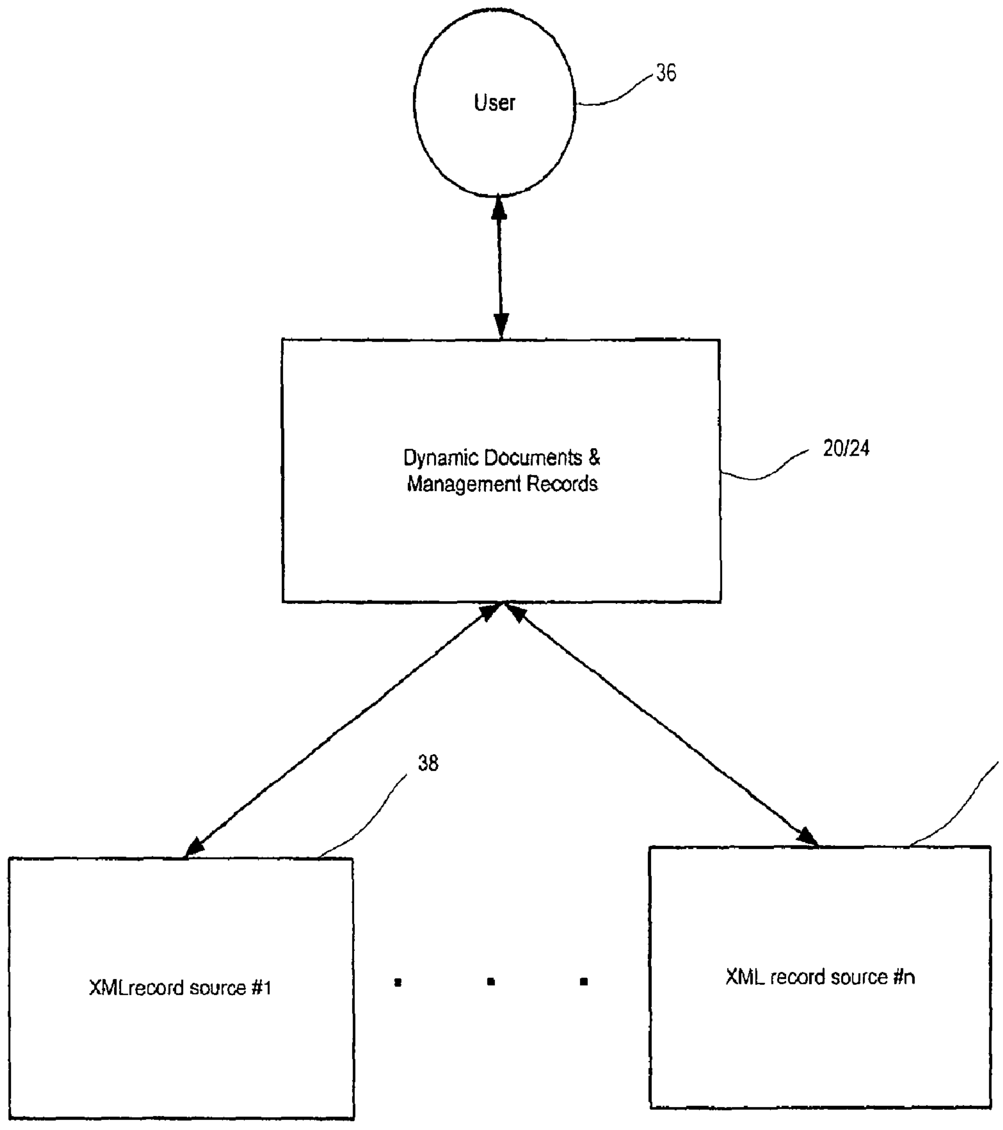

User
36
Dynamic Documents & Management Records
20/24
38
40
XMLrecord source #1
XML record source #n

Figure 3

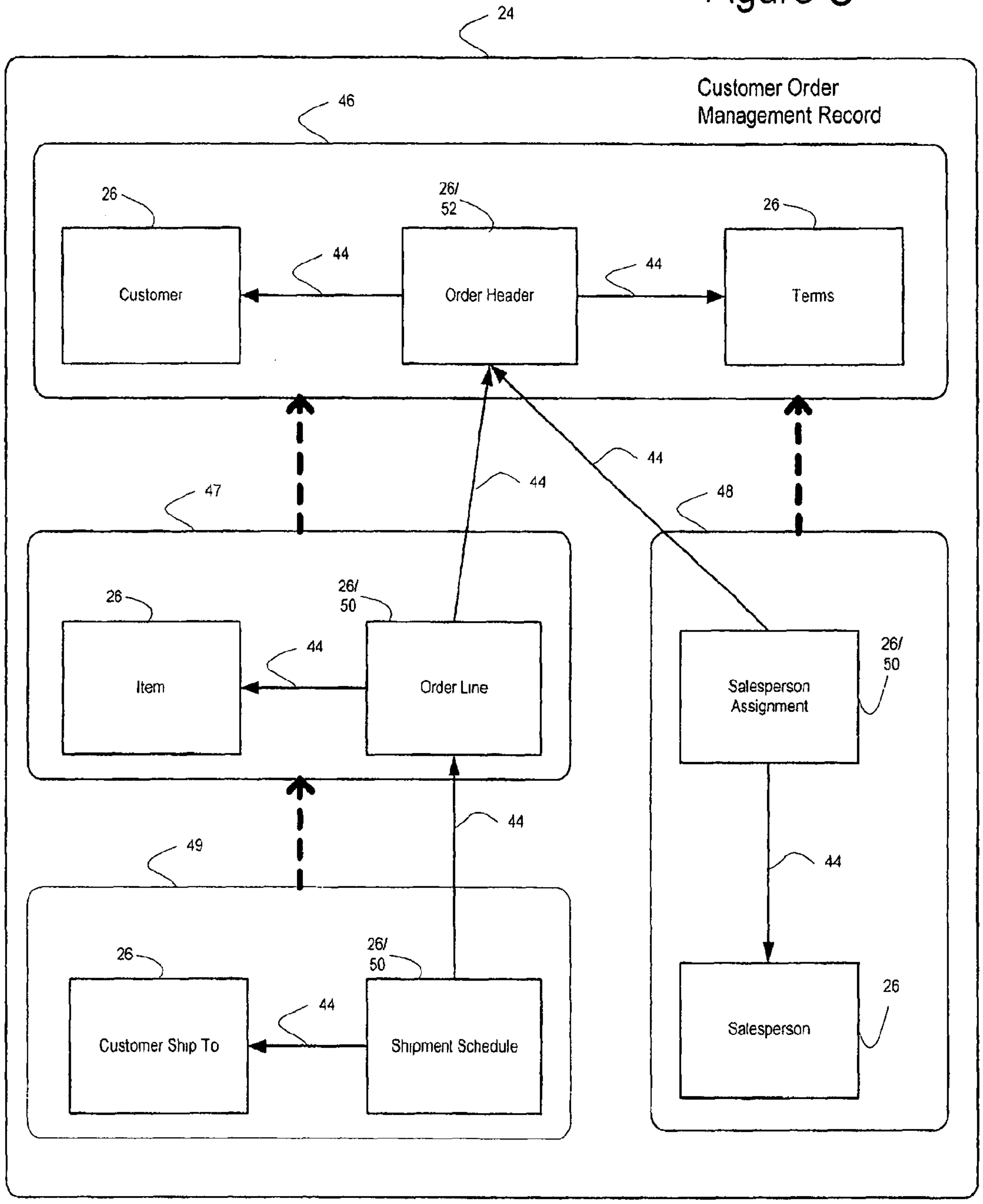

24
Customer Order
Management Record
46
26
Customer
26/
52
Order Header
26
Terms
44
44
44
44
47
48
26
Item
26/
50
Order Line
44
Salesperson
Assignment
26/
50
44
49
44
26
Customer Ship To
26/
50
Shipment Schedule
44
Salesperson
26

Figure 4A

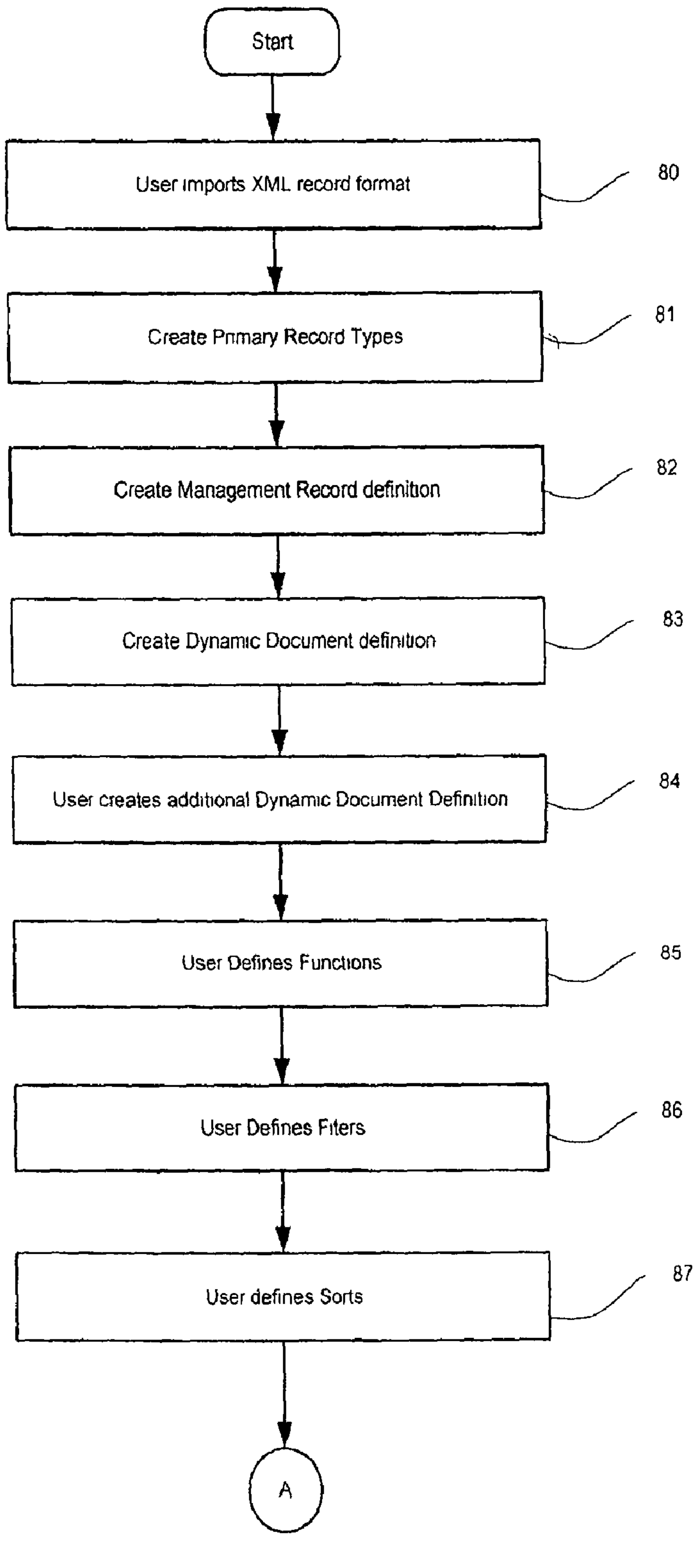

Start
User imports XML record format
80
Create Primary Record Types
81
Create Management Record definition
82
Create Dynamic Document definition
83
User creates additional Dynamic Document Definition
84
User Defines Functions
85
User Defines Filters
86
User defines Sorts
87
A

Figure 4B

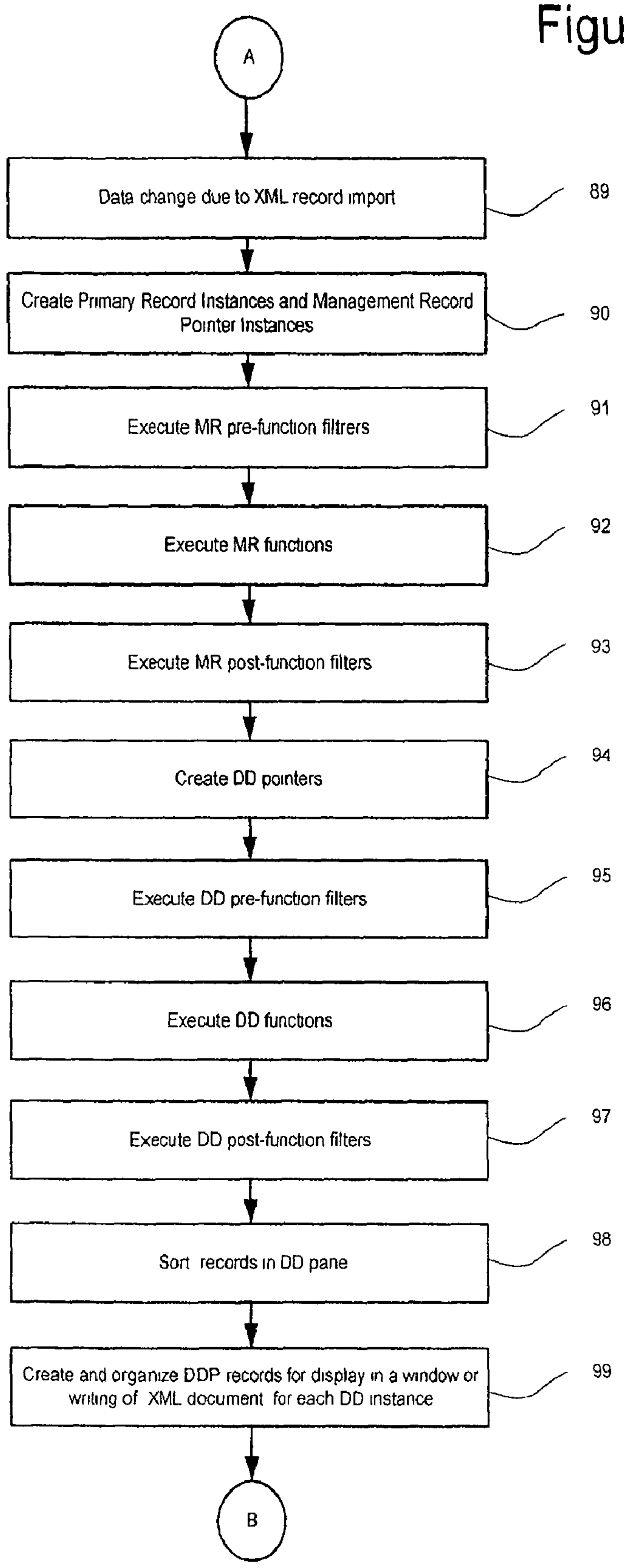

A
Data change due to XML record import
89
Create Primary Record Instances and Management Record Pointer Instances
90
Execute MR pre-function filtrers
91
Execute MR functions
92
Execute MR post-function filters
93
Create DD pointers
94
Execute DD pre-function filters
95
Execute DD functions
96
Execute DD post-function filters
97
Sort records in DD pane
98
Create and organize DDP records for display in a window or writing of XML document for each DD instance
99
B

Figure 4C

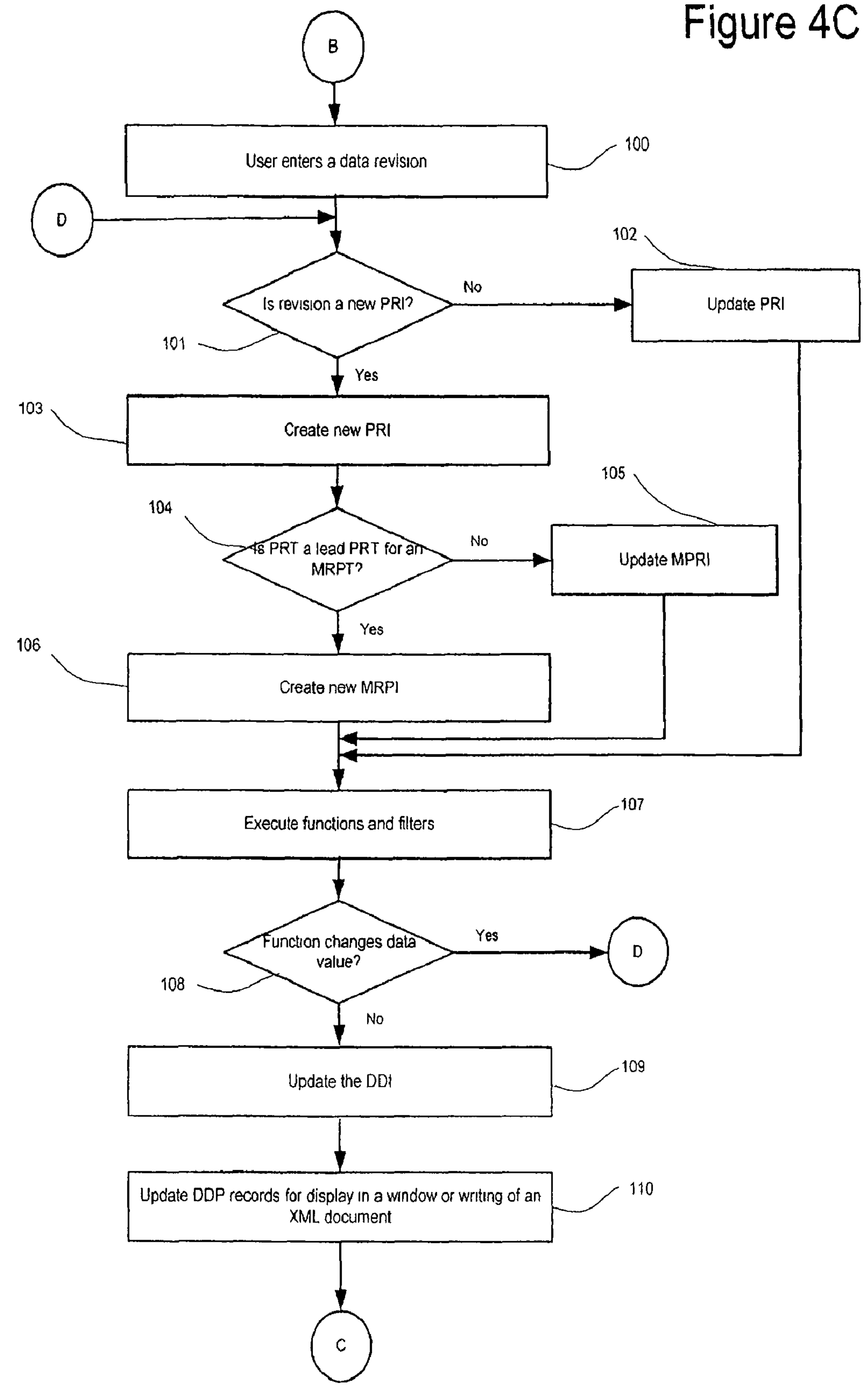

B
User enters a data revision
100
D
Is revision a new PRI?
101
No
Update PRI
102
Yes
Create new PRI
103
Is PRT a lead PRT for an MRPT?
104
No
Update MPRI
105
Yes
Create new MRPI
106
Execute functions and filters
107
Function changes data value?
108
Yes
D
No
Update the DDI
109
Update DDP records for display in a window or writing of an XML document
110
C

Figure 4D

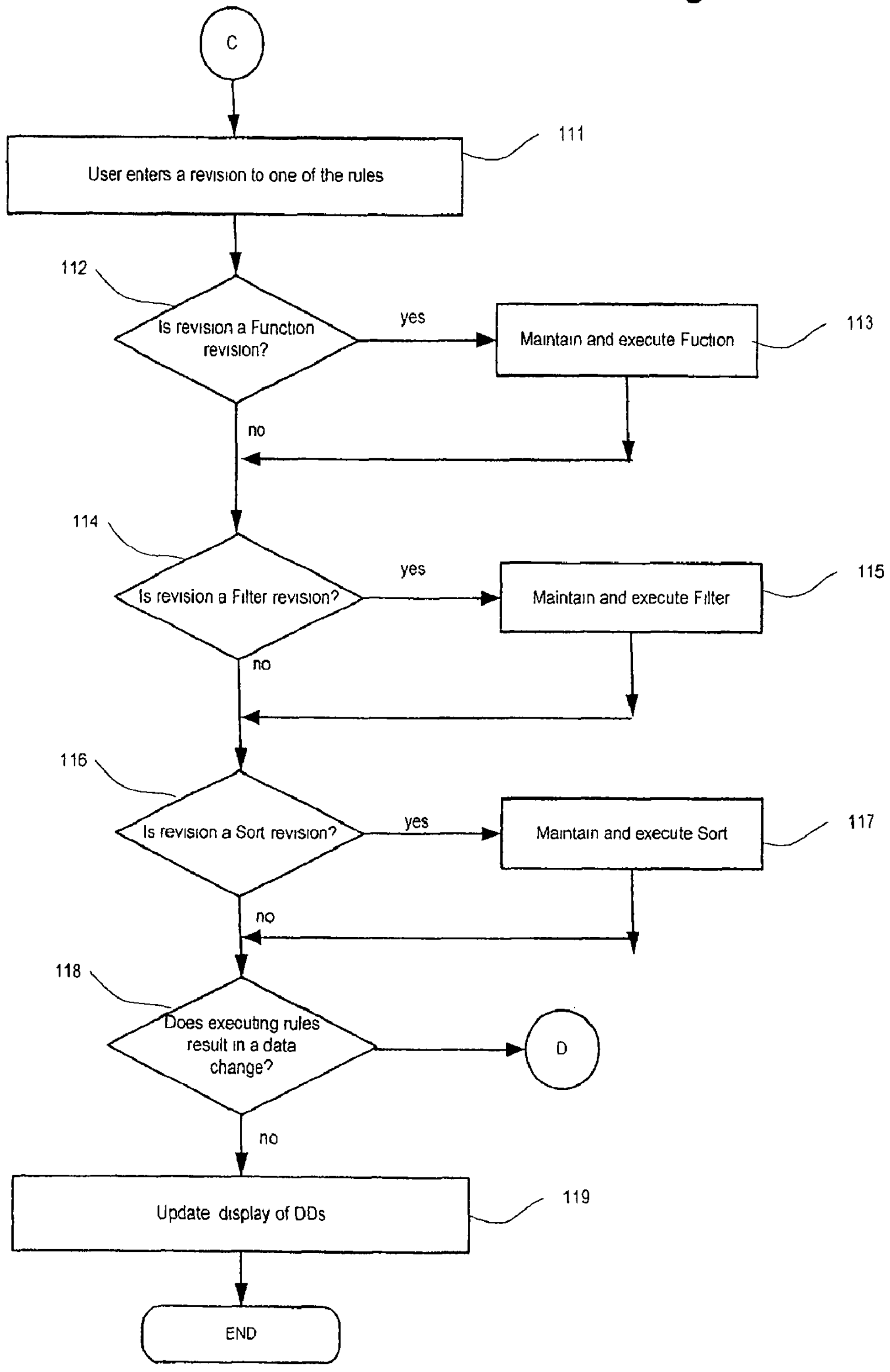

C
User enters a revision to one of the rules
111
112
Is revision a Function revision?
yes
Maintain and execute Fuction
113
no
114
Is revision a Filter revision?
yes
Maintain and execute Filter
115
no
116
Is revision a Sort revision?
yes
Maintain and execute Sort
117
no
118
Does executing rules result in a data change?
D
no
Update display of DDs
119
END

Figure 5

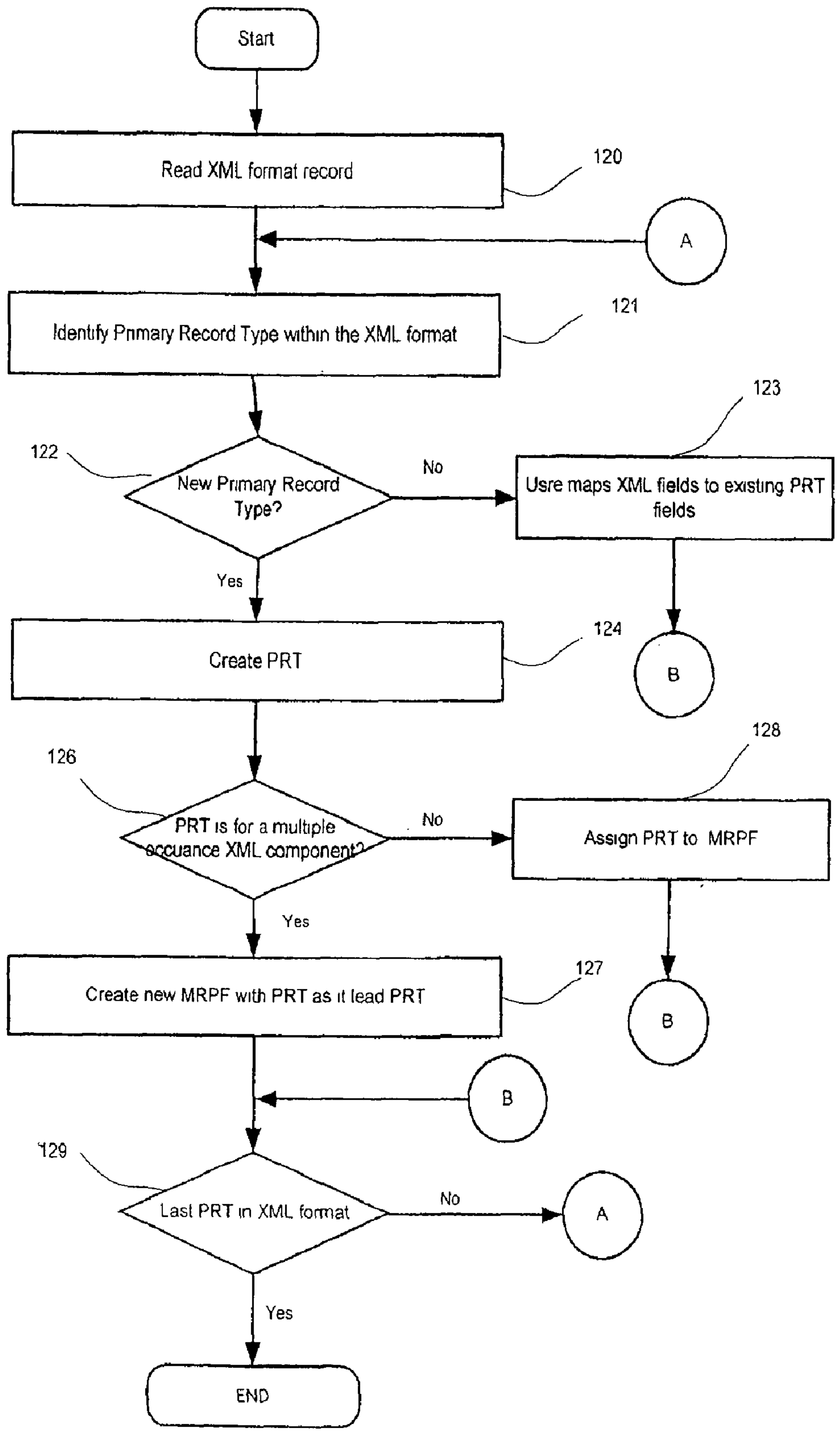

Start
Read XML format record
120
A
Identify Primary Record Type within the XML format
121
122
New Primary Record Type?
No
Usre maps XML fields to existing PRT fields
123
B
Yes
Create PRT
124
126
PRT is for a multiple occuance XML component?
No
Assign PRT to MRPF
128
B
Yes
Create new MRPF with PRT as it lead PRT
127
B
129
Last PRT in XML format
No
A
Yes
END

Figure 6

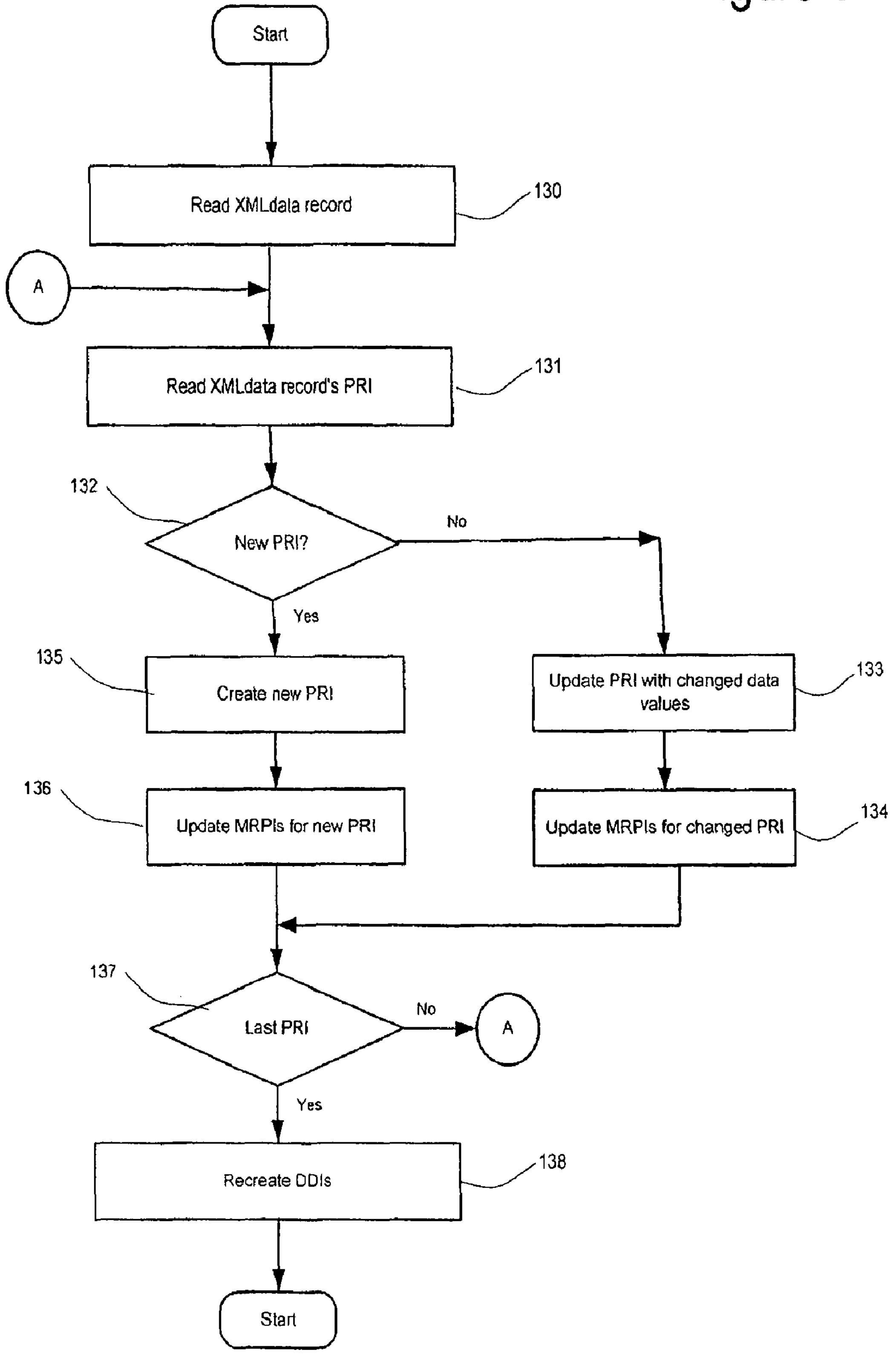

Start
Read XMLdata record
130
A
Read XMLdata record's PRI
131
132
New PRI?
No
Yes
135
Create new PRI
Update PRI with changed data values
133
136
Update MRPIs for new PRI
Update MRPIs for changed PRI
134
137
Last PRI
No
A
Yes
Recreate DDIs
138
Start

Figure 7A

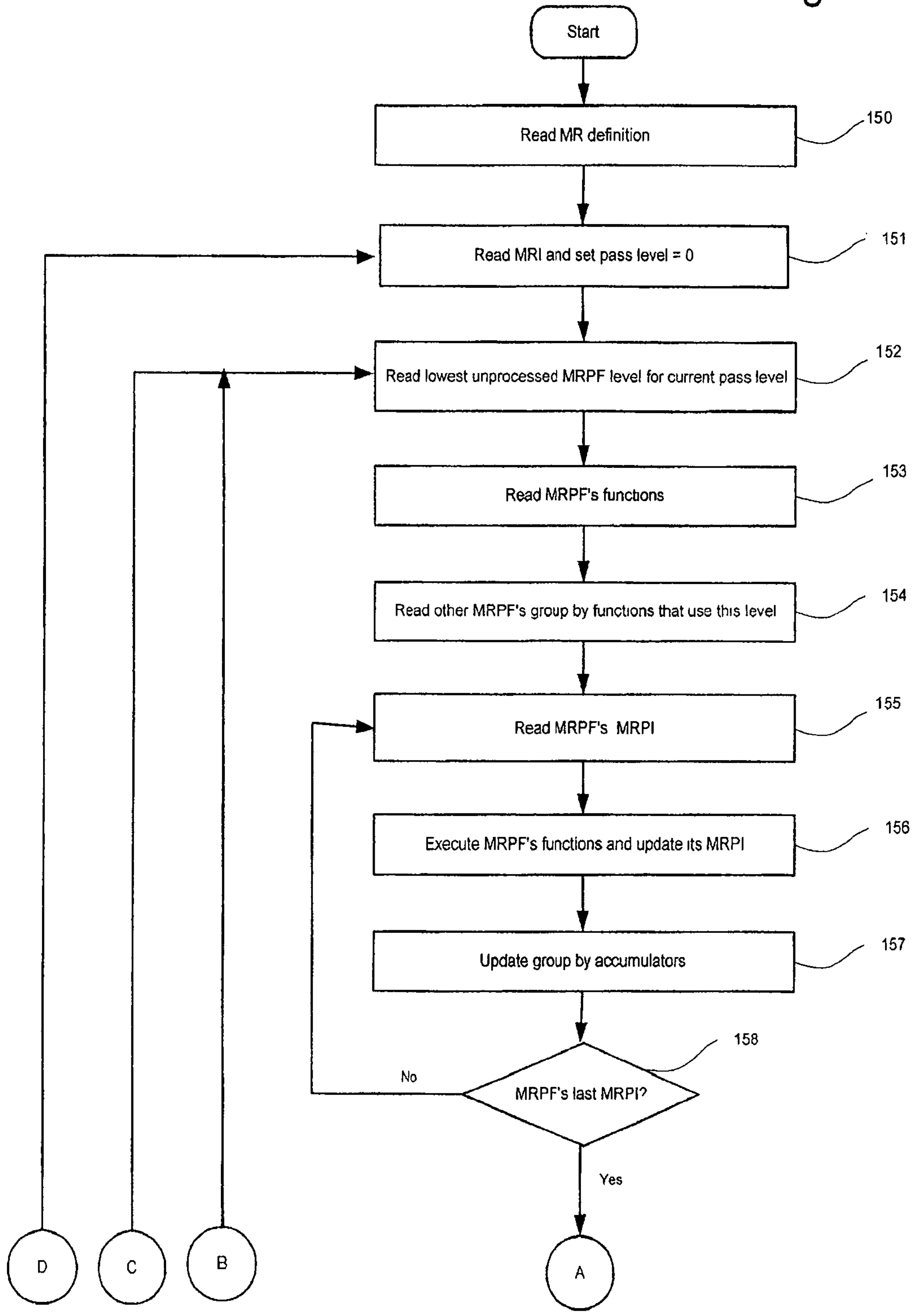

Start
Read MR definition
150
Read MRI and set pass level = 0
151
Read lowest unprocessed MRPF level for current pass level
152
Read MRPF's functions
153
Read other MRPF's group by functions that use this level
154
Read MRPF's MRPI
155
Execute MRPF's functions and update its MRPI
156
Update group by accumulators
157
MRPF's last MRPI?
158
No
Yes
D
C
B
A

Figure 7B

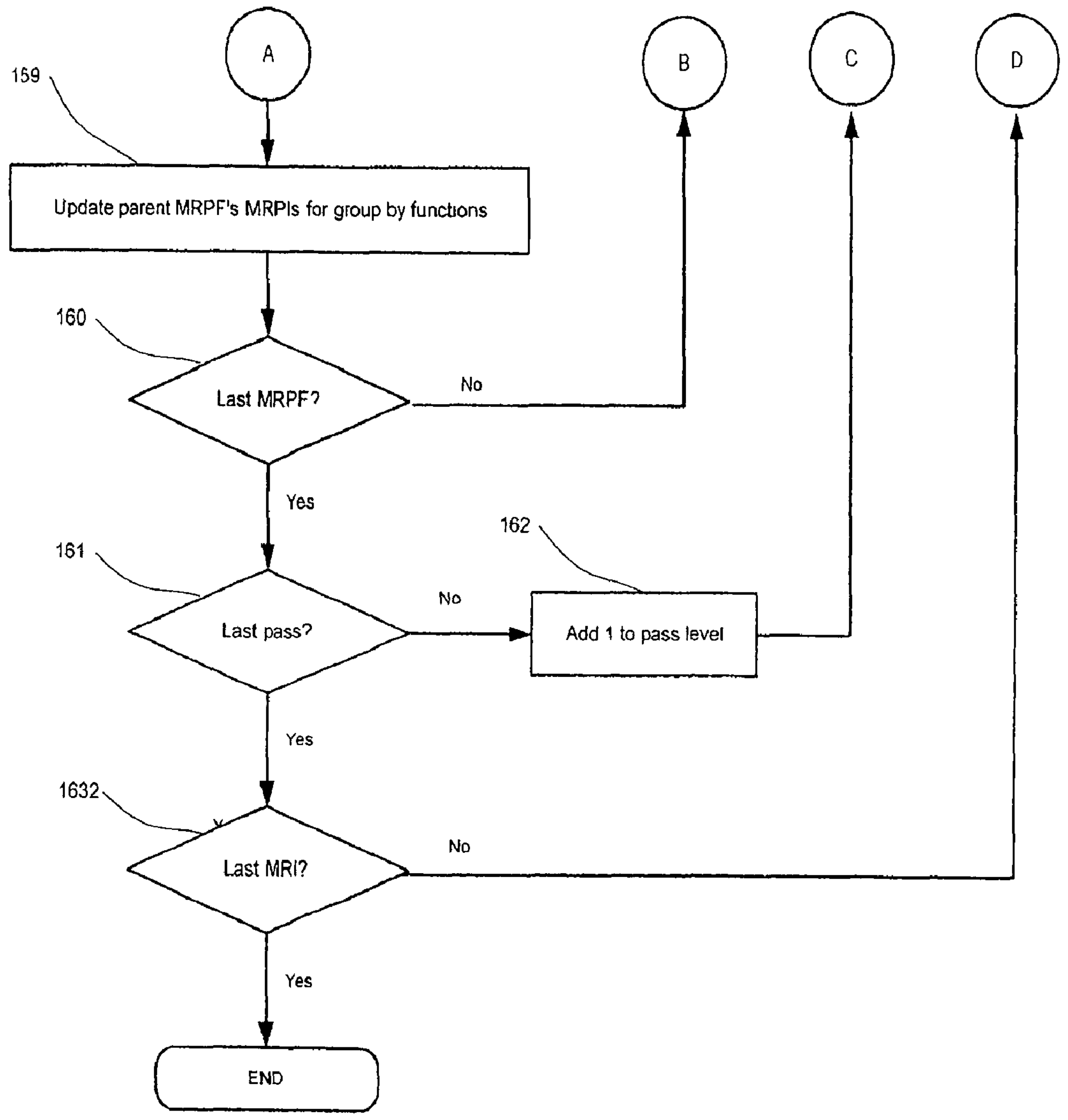

A
B
C
D
159
Update parent MRPF's MRPIs for group by functions
160
Last MRPF?
No
Yes
161
Last pass?
No
162
Add 1 to pass level
Yes
1632
Last MRI?
No
Yes
END

Figure 8A

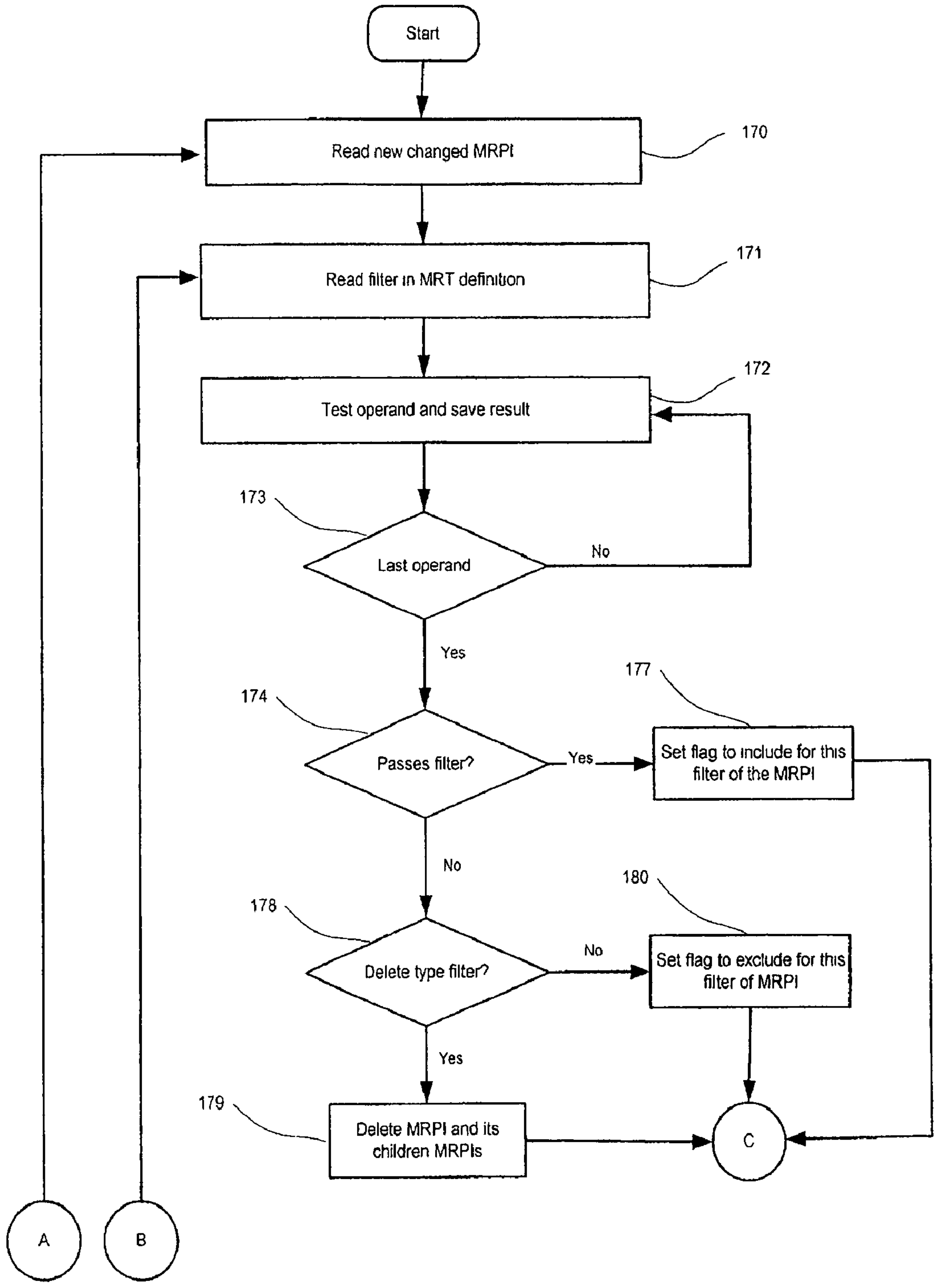

Start
Read new changed MRPI
170
Read filter in MRT definition
171
Test operand and save result
172
173
Last operand
No
Yes
174
Passes filter?
Yes
177
Set flag to include for this filter of the MRPI
No
178
Delete type filter?
No
180
Set flag to exclude for this filter of MRPI
Yes
179
Delete MRPI and its children MRPIs
C
A
B

Figure 8B

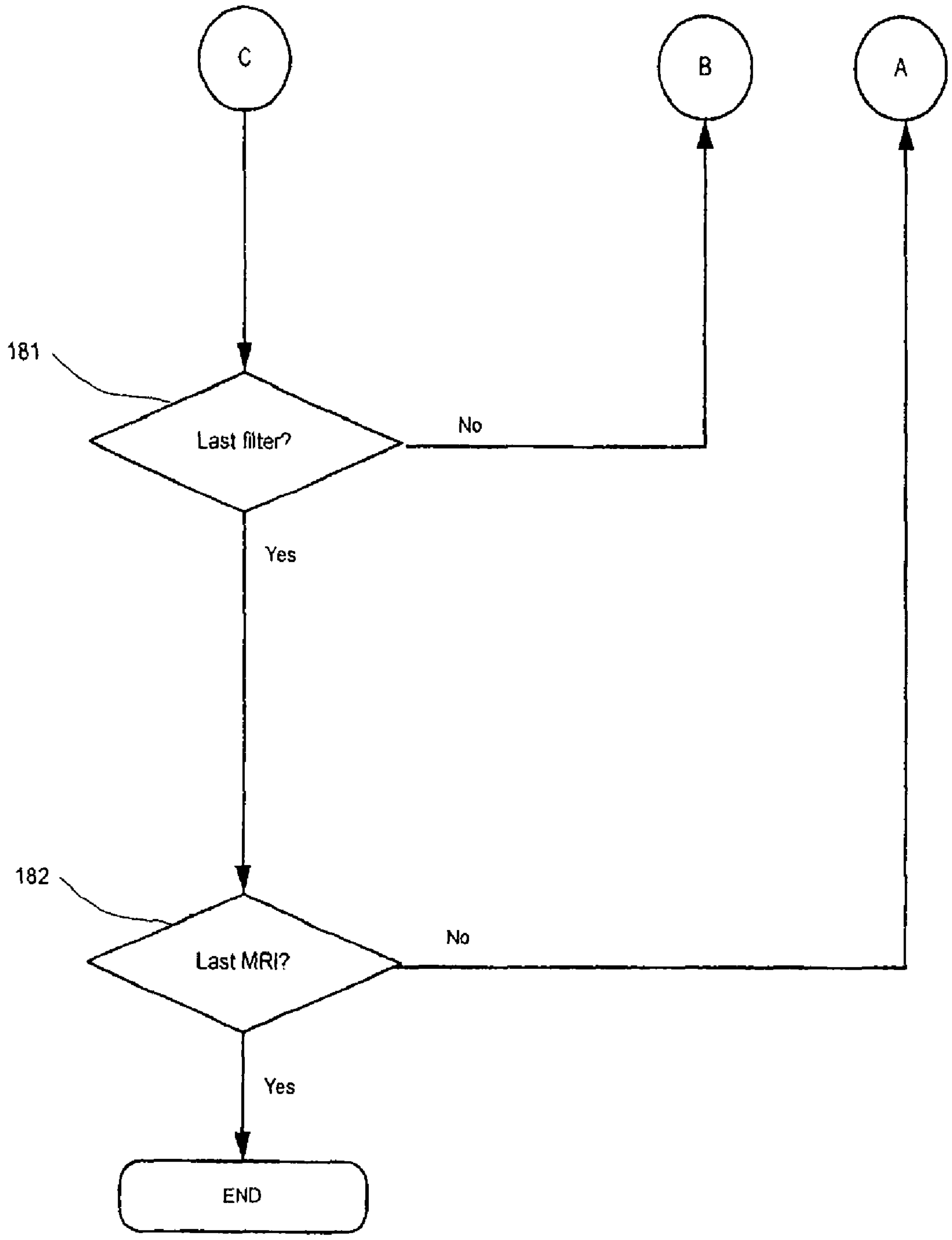


Figure 9A

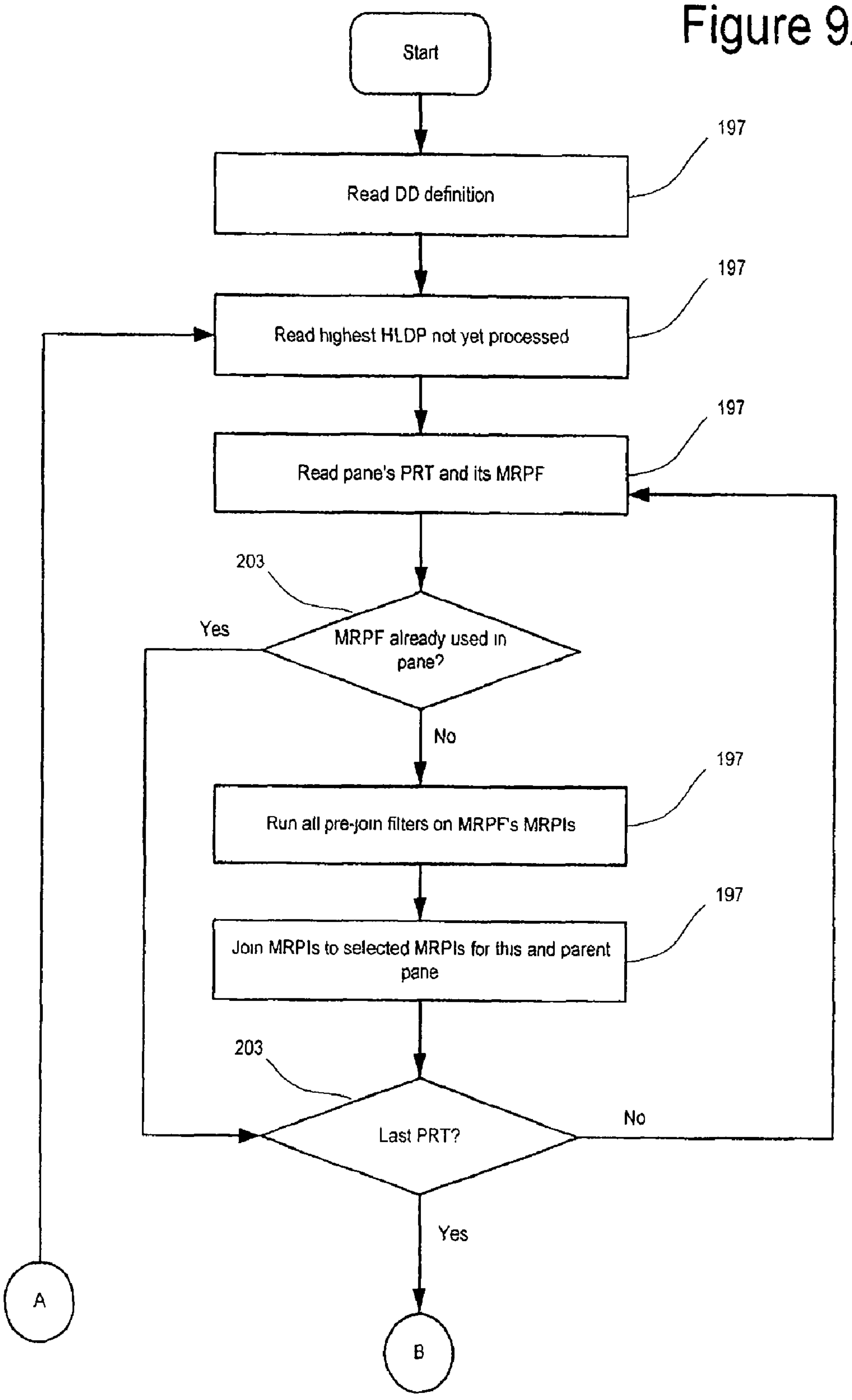

Start
Read DD definition
197
Read highest HLDP not yet processed
197
Read pane's PRT and its MRPF
197
203
MRPF already used in pane?
Yes
No
Run all pre-join filters on MRPF's MRPIs
197
Join MRPIs to selected MRPIs for this and parent pane
197
203
Last PRT?
No
Yes
A
B

Figure 9B

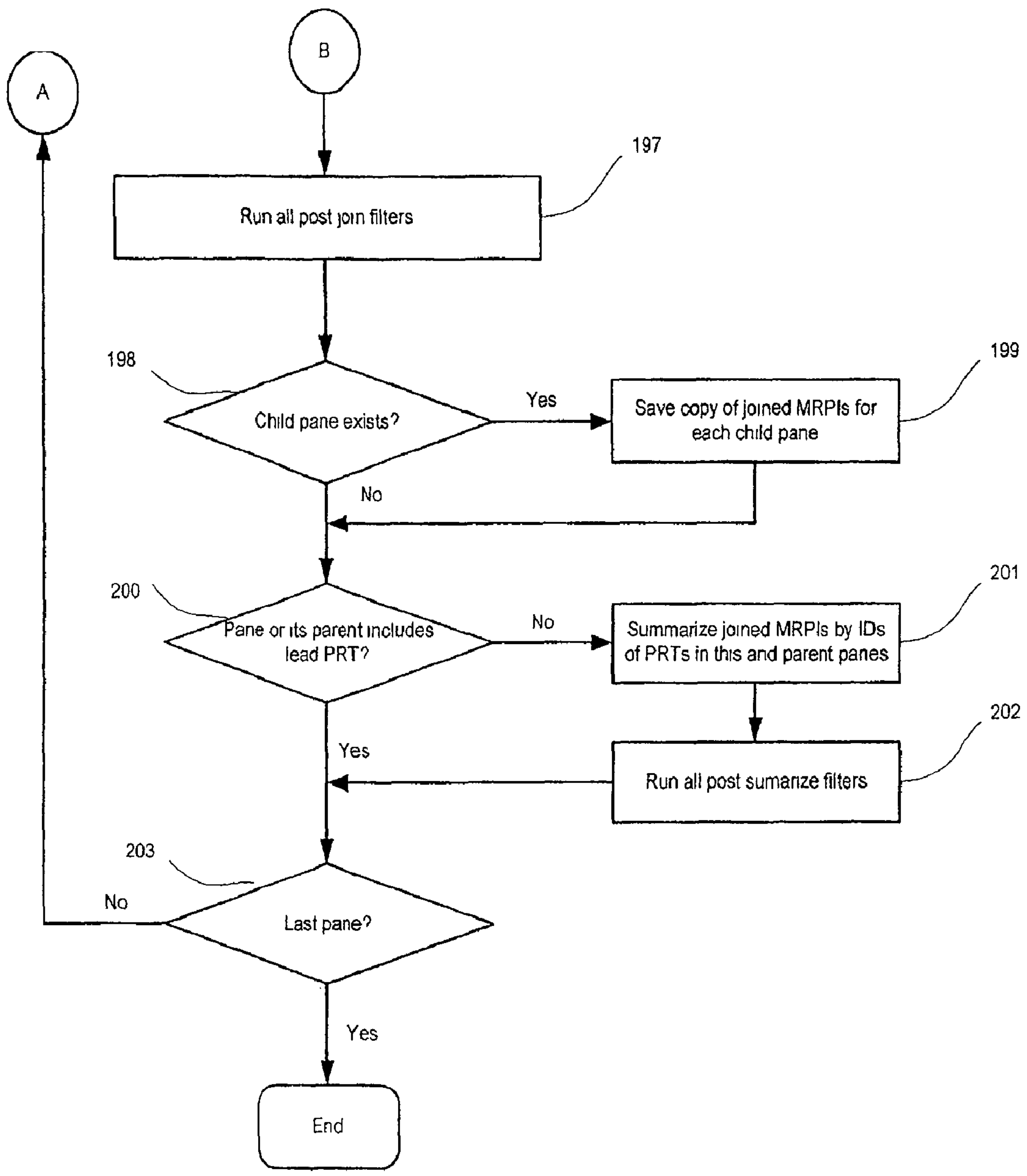

A
B
197
Run all post join filters
198
Child pane exists?
Yes
No
199
Save copy of joined MRPIs for each child pane
200
Pane or its parent includes lead PRT?
No
Yes
201
Summarize joined MRPIs by IDs of PRTs in this and parent panes
202
Run all post sumarize filters
203
Last pane?
No
Yes
End

Figure 10

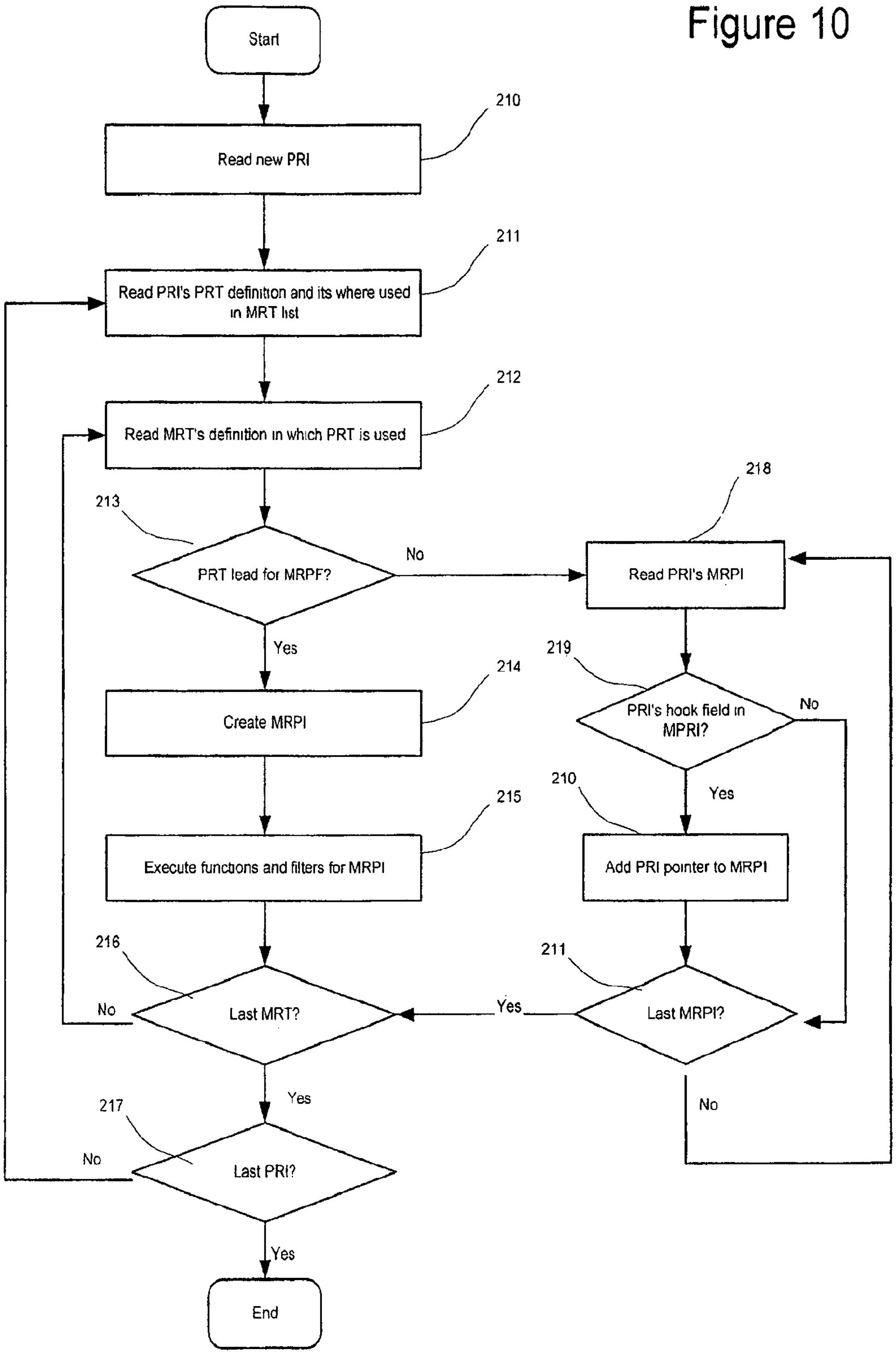

Start
210
Read new PRI
211
Read PRI's PRT definition and its where used in MRT list
212
Read MRT's definition in which PRT is used
213
PRT lead for MRPF?
No
Yes
218
Read PRI's MRPI
219
PRI's hook field in MPRI?
No
Yes
214
Create MRPI
215
Execute functions and filters for MRPI
210
Add PRI pointer to MRPI
216
Last MRT?
No
Yes
211
Last MRPI?
Yes
No
217
Last PRI?
No
Yes
End

Figure 11A

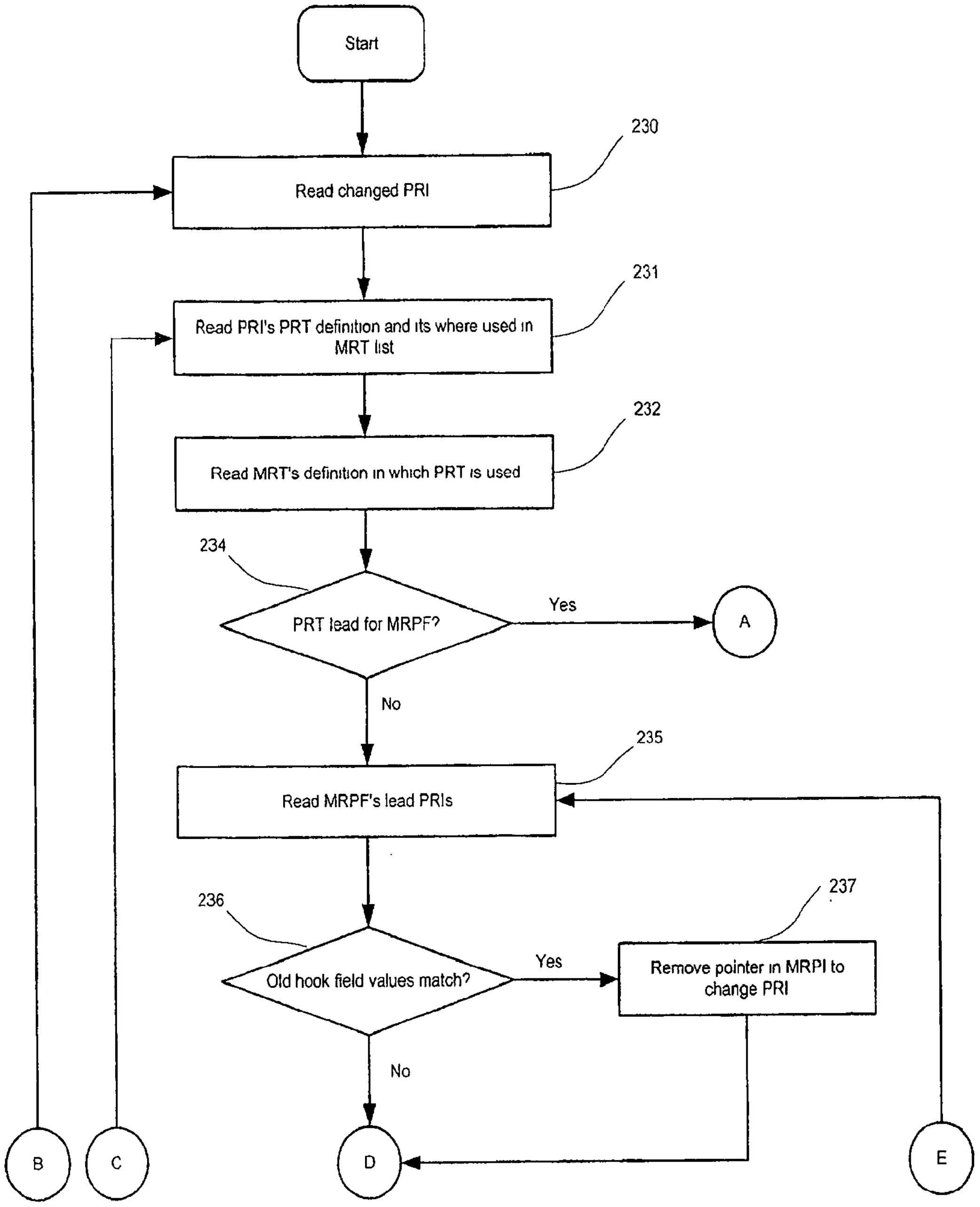

Start
230
Read changed PRI
231
Read PRI's PRT definition and its where used in MRT list
232
Read MRT's definition in which PRT is used
234
PRT lead for MRPF?
Yes
A
No
235
Read MRPF's lead PRIs
236
Old hook field values match?
Yes
237
Remove pointer in MRPI to change PRI
No
B
C
D
E

Figure 11B

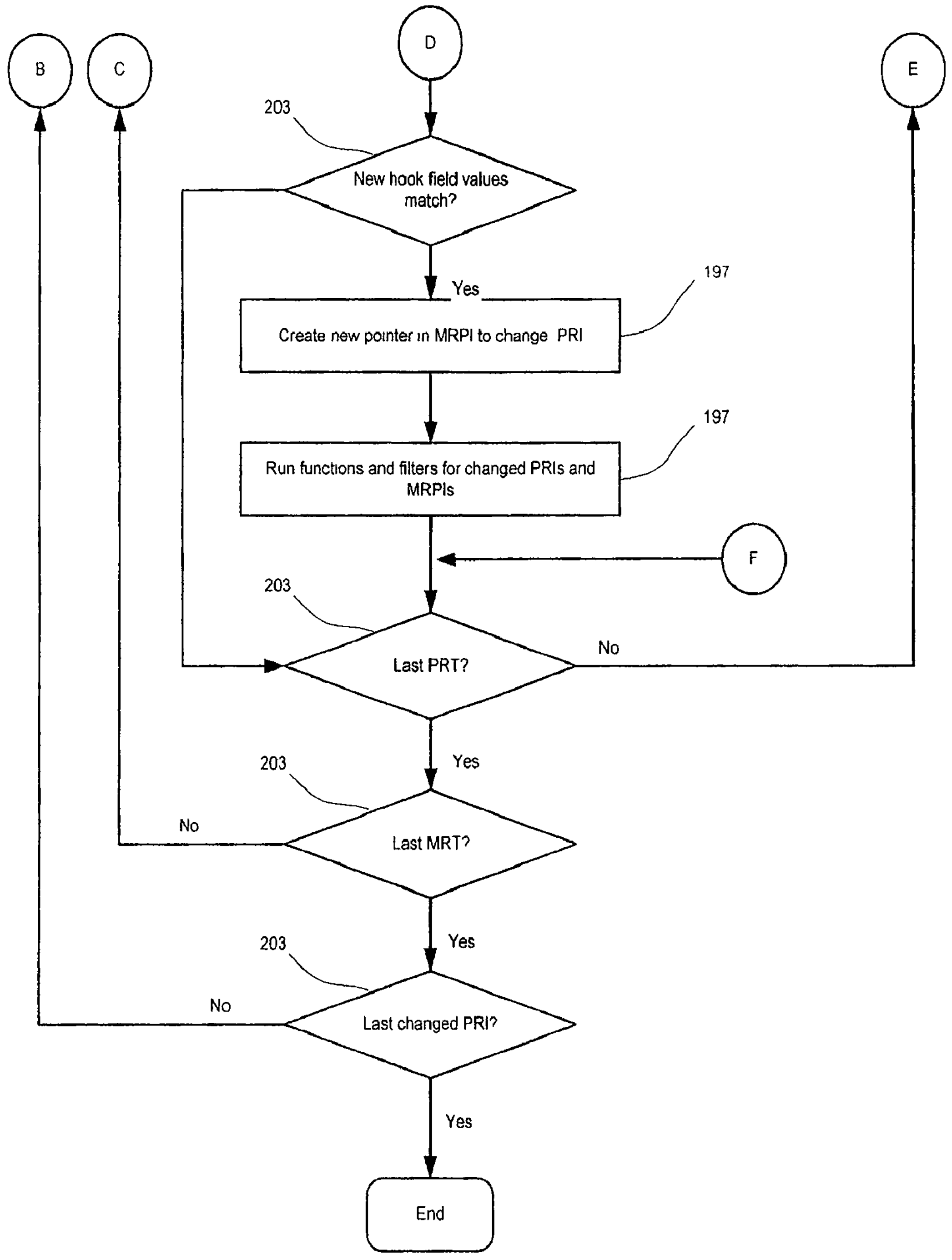

D
B
C
E
203
New hook field values match?
Yes
197
Create new pointer in MRPI to change PRI
197
Run functions and filters for changed PRIs and MRPIs
F
203
Last PRT?
No
Yes
203
Last MRT?
No
Yes
203
Last changed PRI?
No
Yes
End

Figure 11C

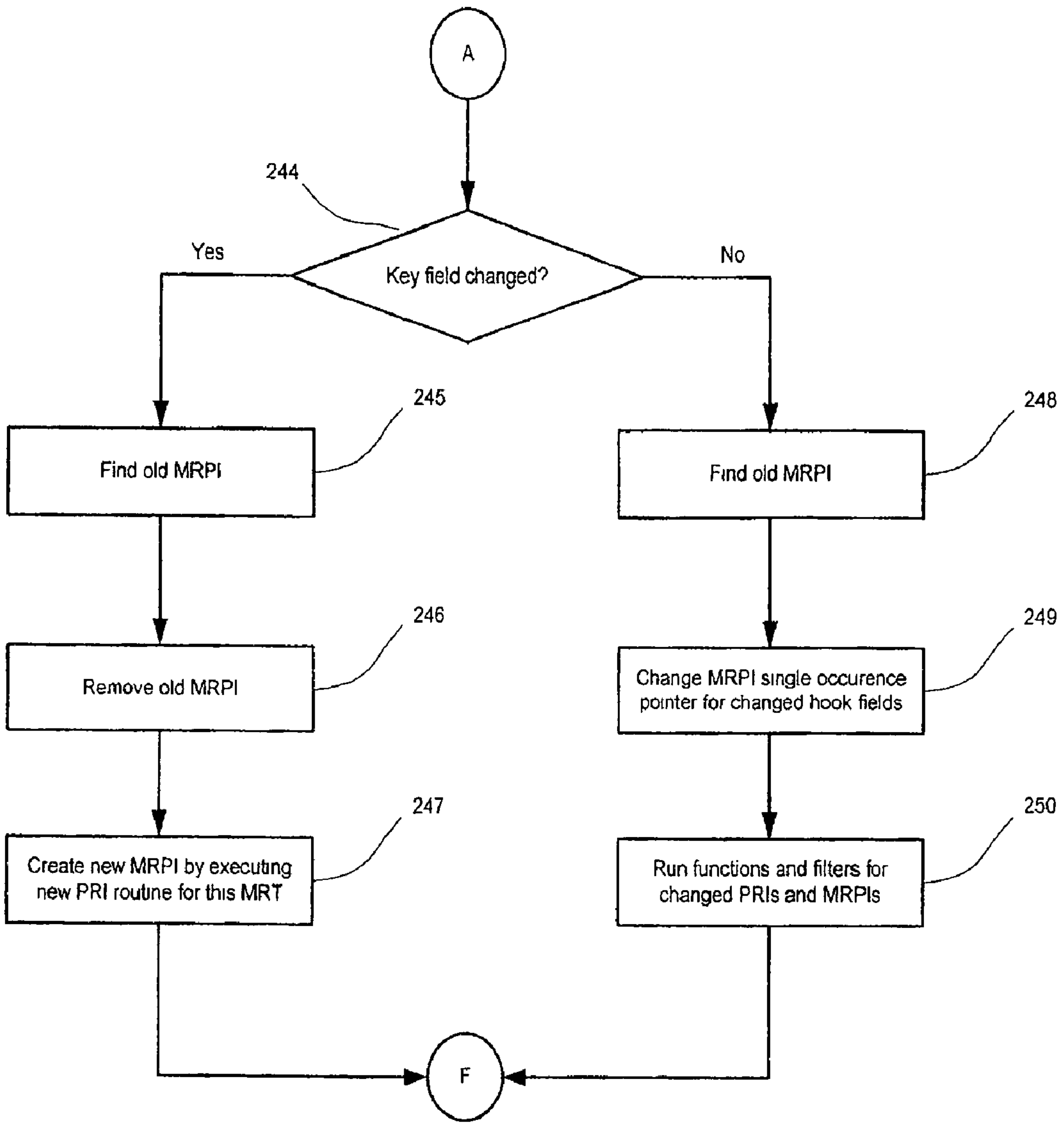

A
244
Key field changed?
Yes
No
245
Find old MRPI
246
Remove old MRPI
247
Create new MRPI by executing new PRI routine for this MRT
248
Find old MRPI
249
Change MRPI single occurence pointer for changed hook fields
250
Run functions and filters for changed PRIs and MRPIs
F

Figure 12A

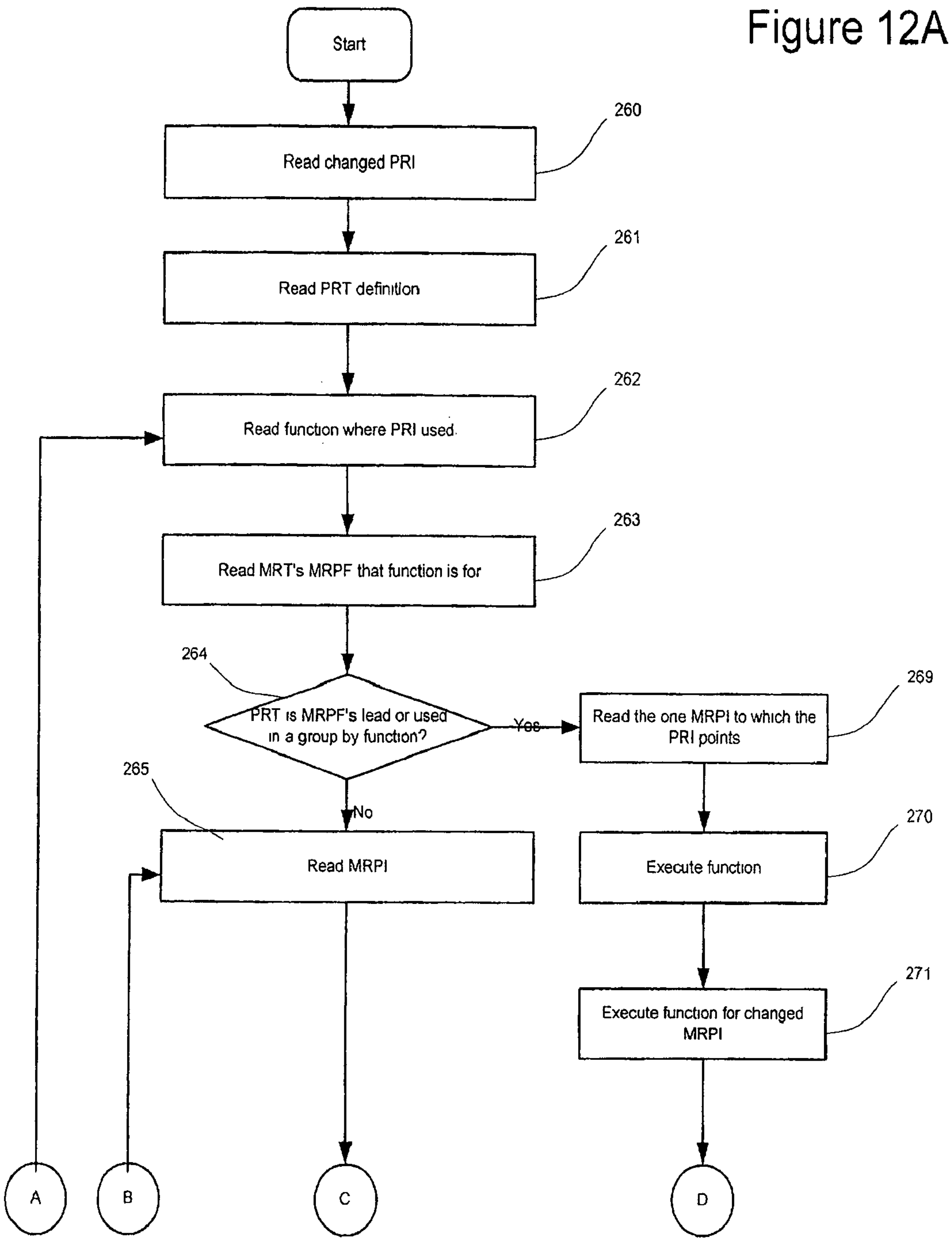

Start
260
Read changed PRI
261
Read PRT definition
262
Read function where PRI used
263
Read MRT's MRPF that function is for
264
PRT is MRPF's lead or used in a group by function?
Yes
No
269
Read the one MRPI to which the PRI points
265
Read MRPI
270
Execute function
271
Execute function for changed MRPI
A
B
C
D

Figure 12B

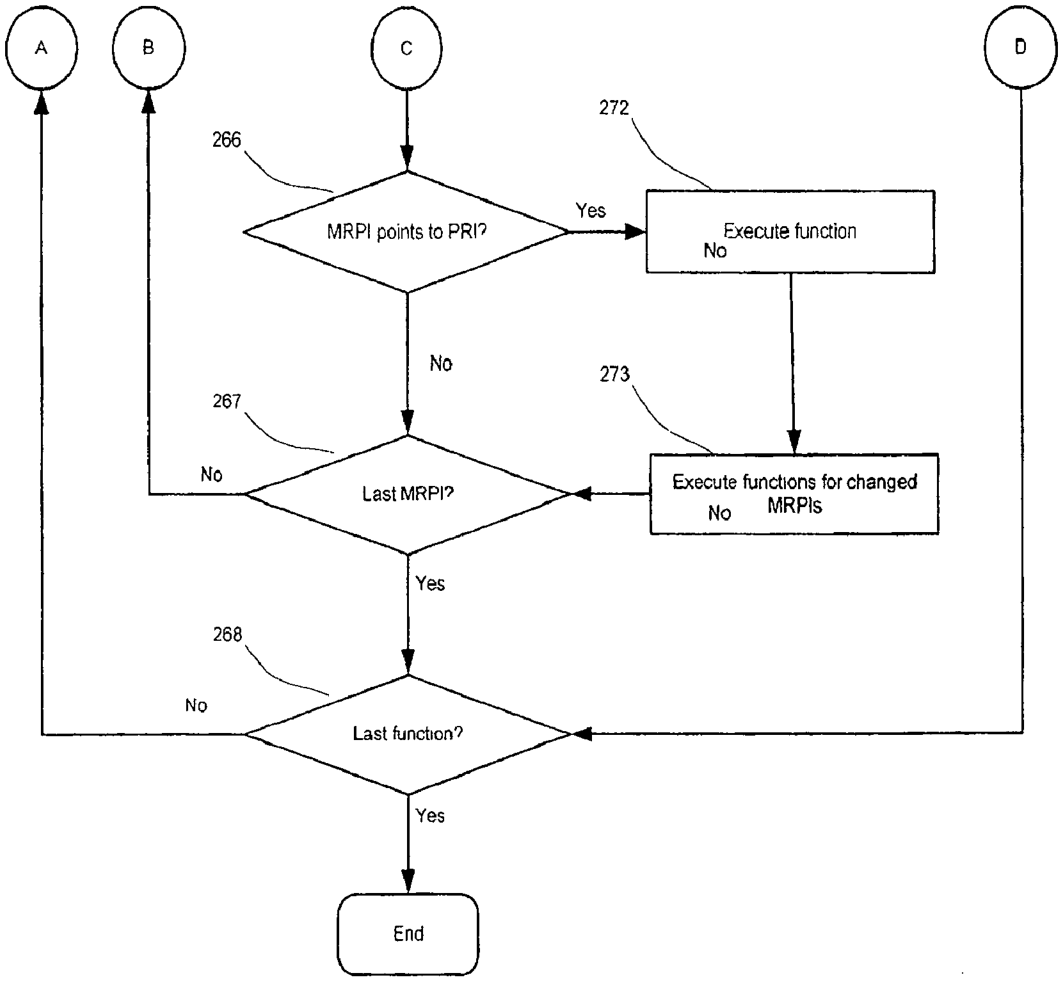

A
B
C
D
266
MRPI points to PRI?
Yes
272
Execute function
No
No
273
267
Last MRPI?
No
Execute functions for changed MRPIs
No
Yes
268
Last function?
No
Yes
End

Figure 13

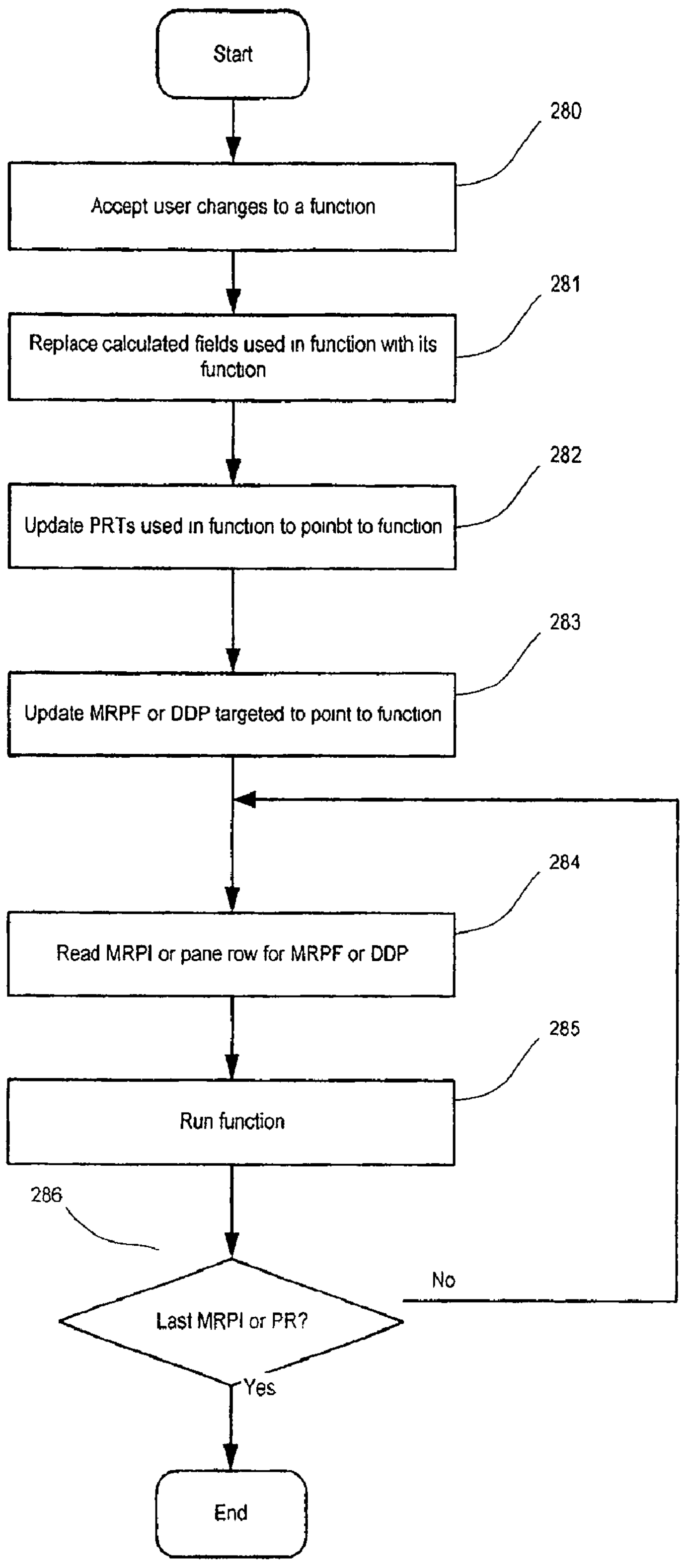

Start
280
Accept user changes to a function
281
Replace calculated fields used in function with its function
282
Update PRTs used in function to poinbt to function
283
Update MRPF or DDP targeted to point to function
284
Read MRPI or pane row for MRPF or DDP
285
Run function
286
Last MRPI or PR?
No
Yes
End

Figure 14

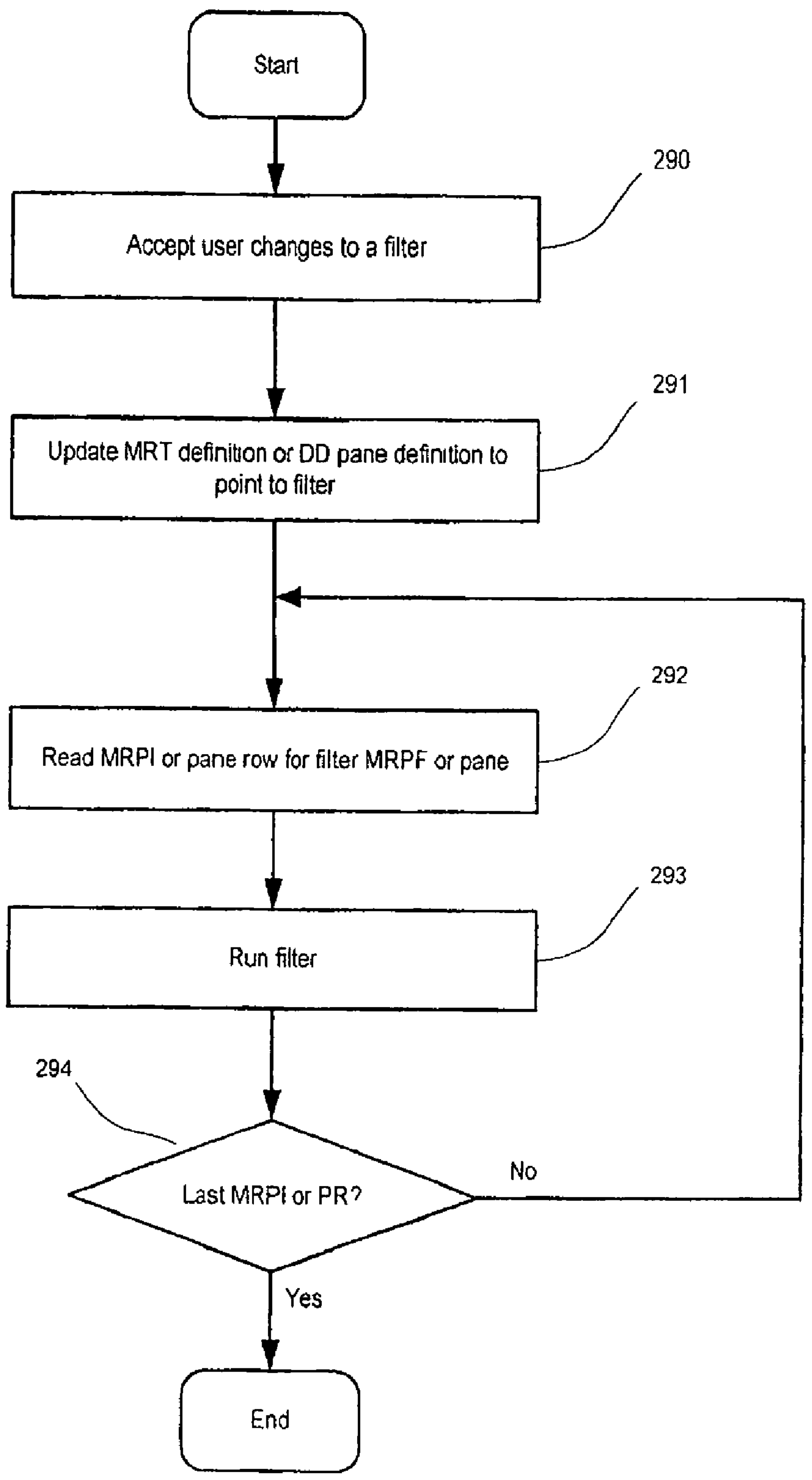

Start
290
Accept user changes to a filter
291
Update MRT definition or DD pane definition to point to filter
292
Read MRPI or pane row for filter MRPF or pane
293
Run filter
294
Last MRPI or PR?
No
Yes
End

Figure 15A

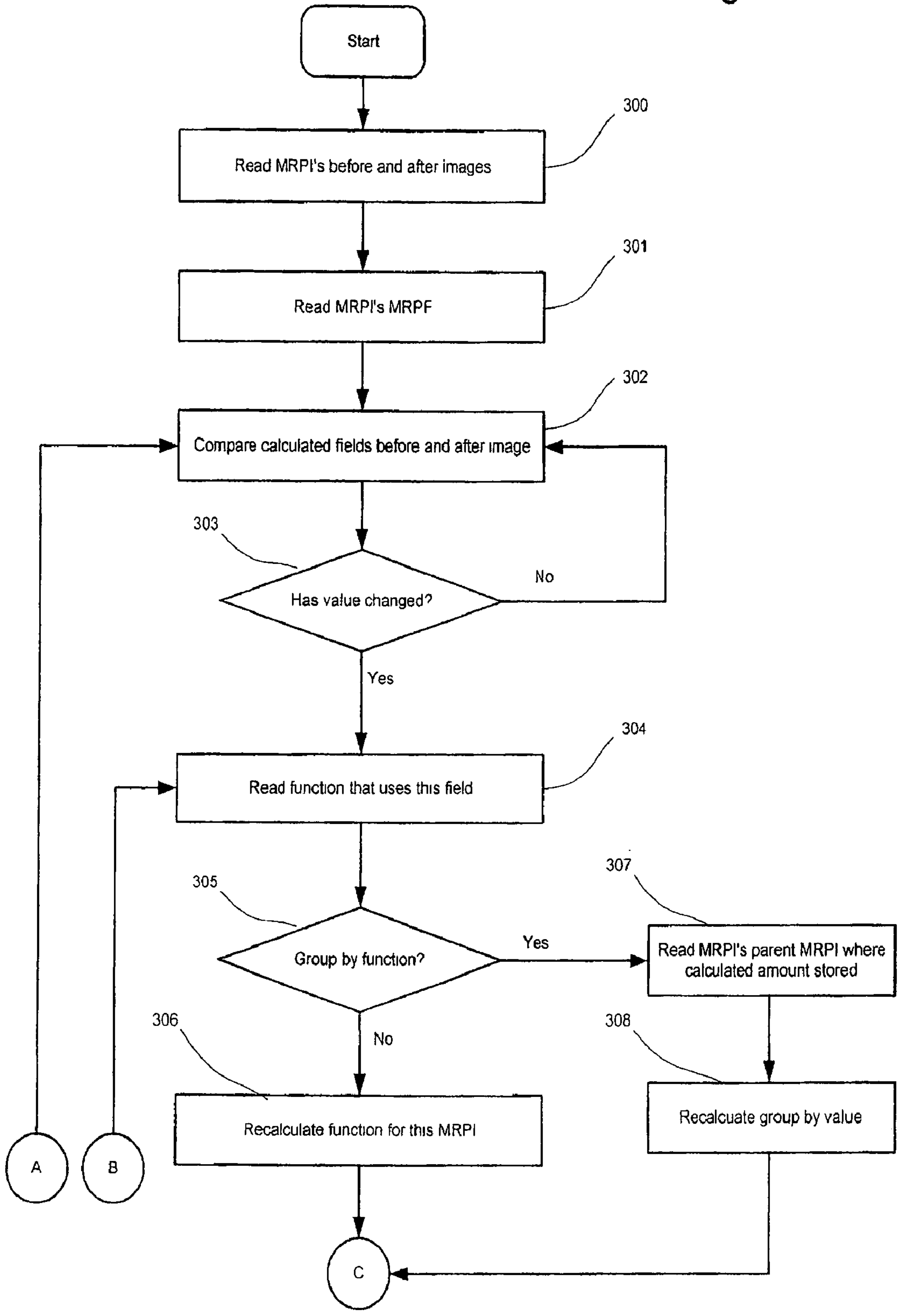

Start
300
Read MRPI's before and after images
301
Read MRPI's MRPF
302
Compare calculated fields before and after image
303
Has value changed?
No
Yes
304
Read function that uses this field
305
Group by function?
Yes
307
Read MRPI's parent MRPI where calculated amount stored
No
306
Recalculate function for this MRPI
308
Recalcuate group by value
A
B
C

Figure 15B

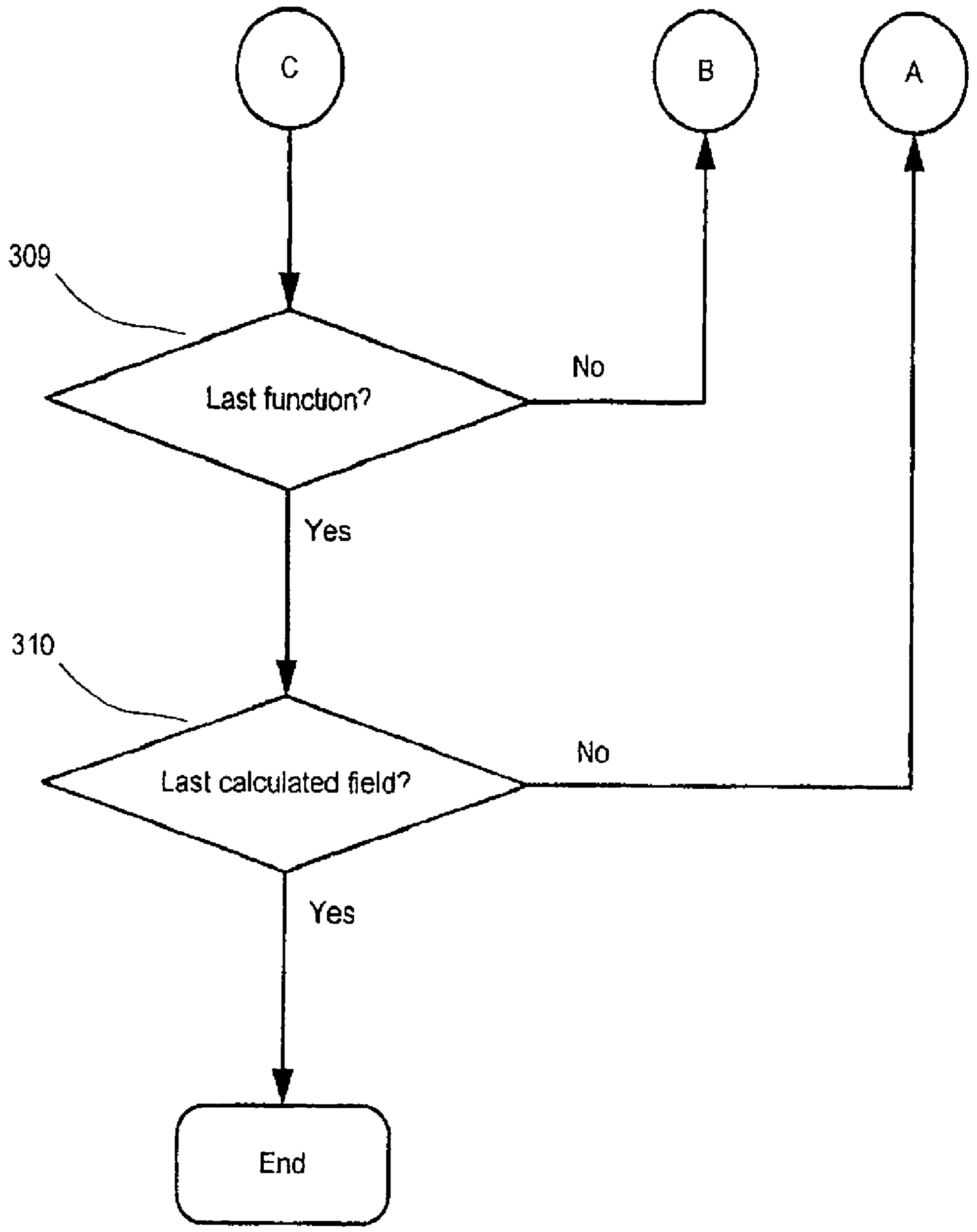

C
B
A
309
Last function?
No
Yes
310
Last calculated field?
No
Yes
End

Figure 16A

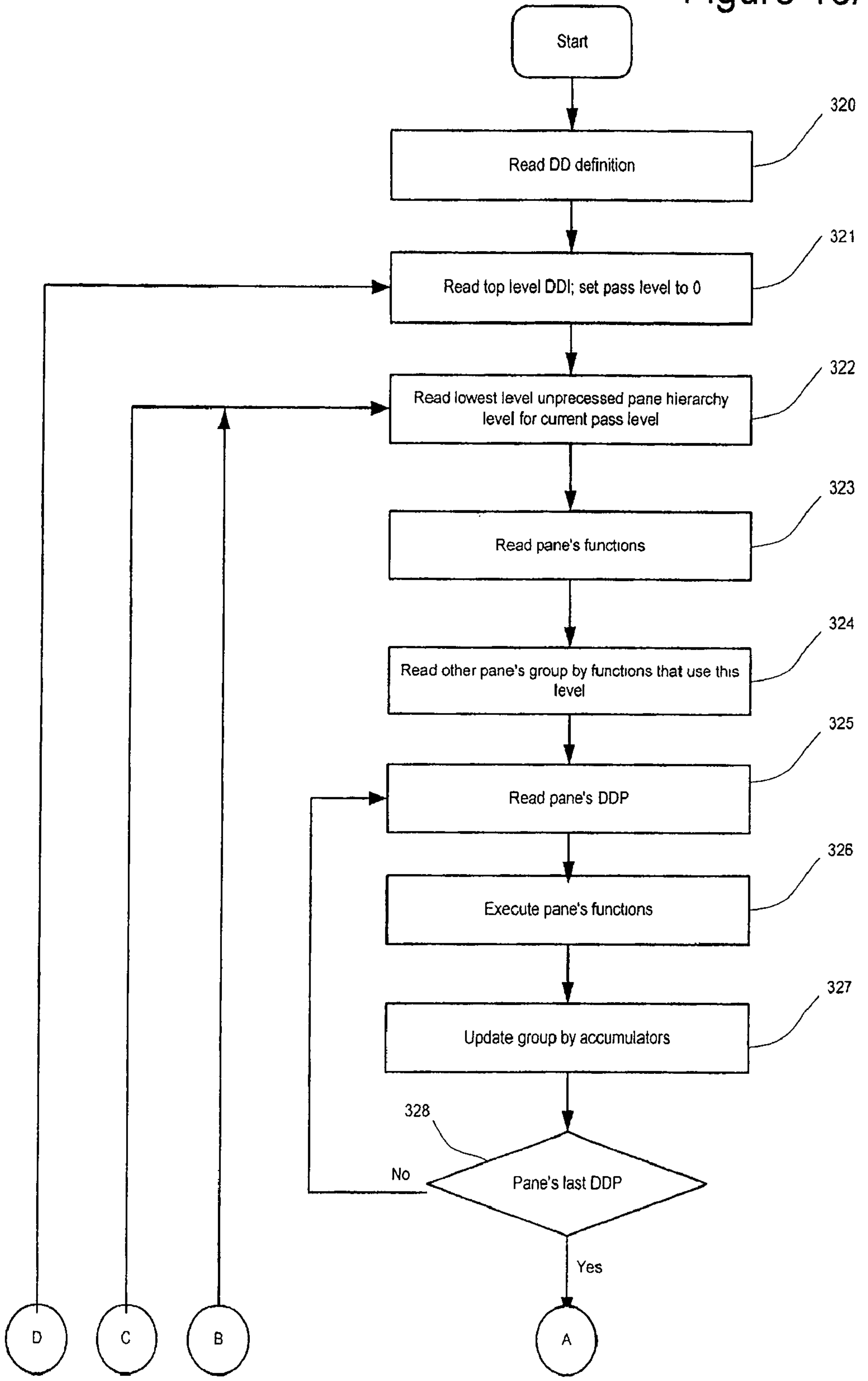

Start
Read DD definition
320
Read top level DDI; set pass level to 0
321
Read lowest level unprecessed pane hierarchy level for current pass level
322
Read pane's functions
323
Read other pane's group by functions that use this level
324
Read pane's DDP
325
Execute pane's functions
326
Update group by accumulators
327
328
Pane's last DDP
No
Yes
D
C
B
A

Figure 16B

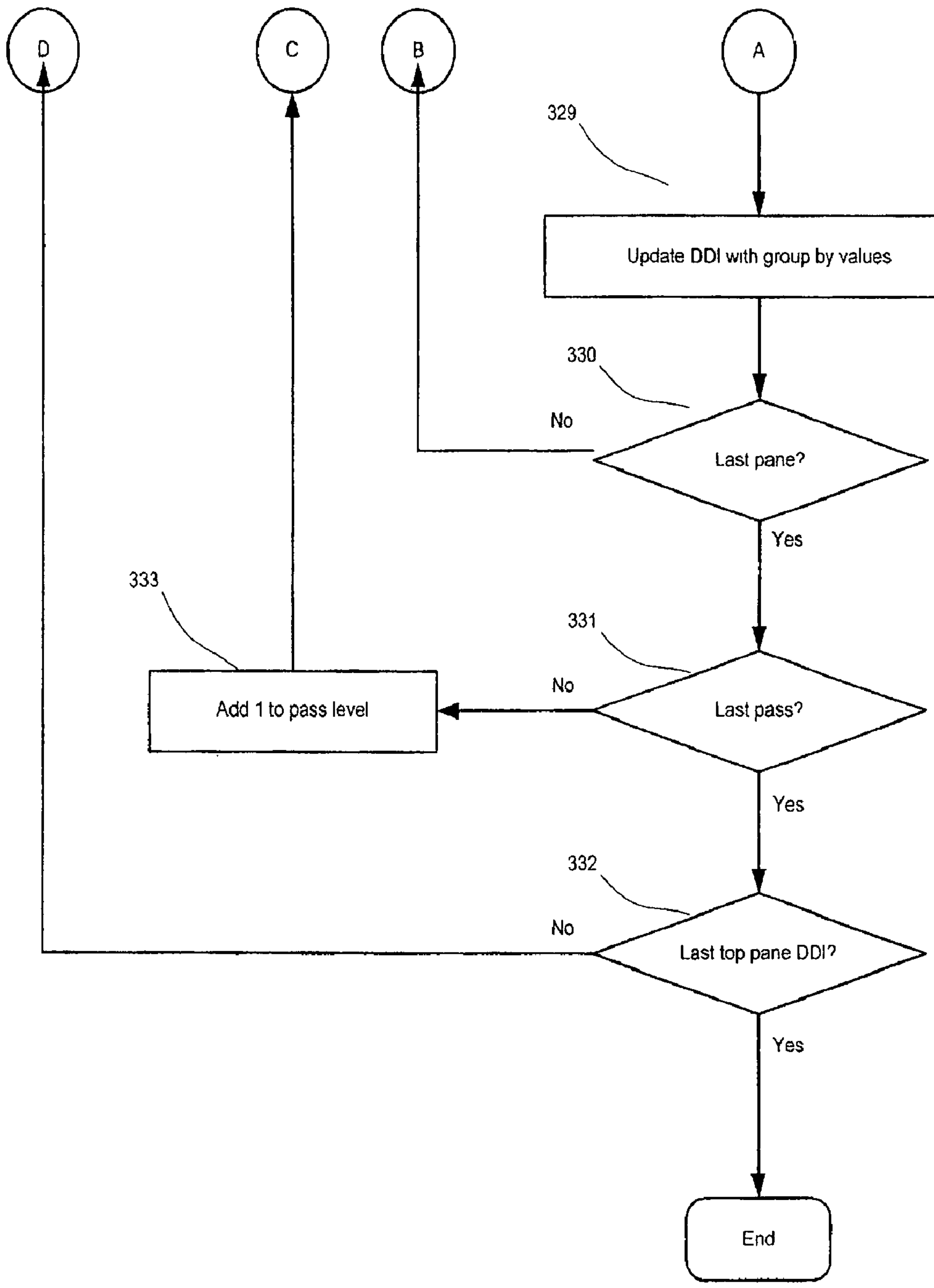

D
C
B
A
329
Update DDI with group by values
330
No
Last pane?
Yes
333
331
No
Add 1 to pass level
Last pass?
Yes
332
No
Last top pane DDI?
Yes
End

Figure 17

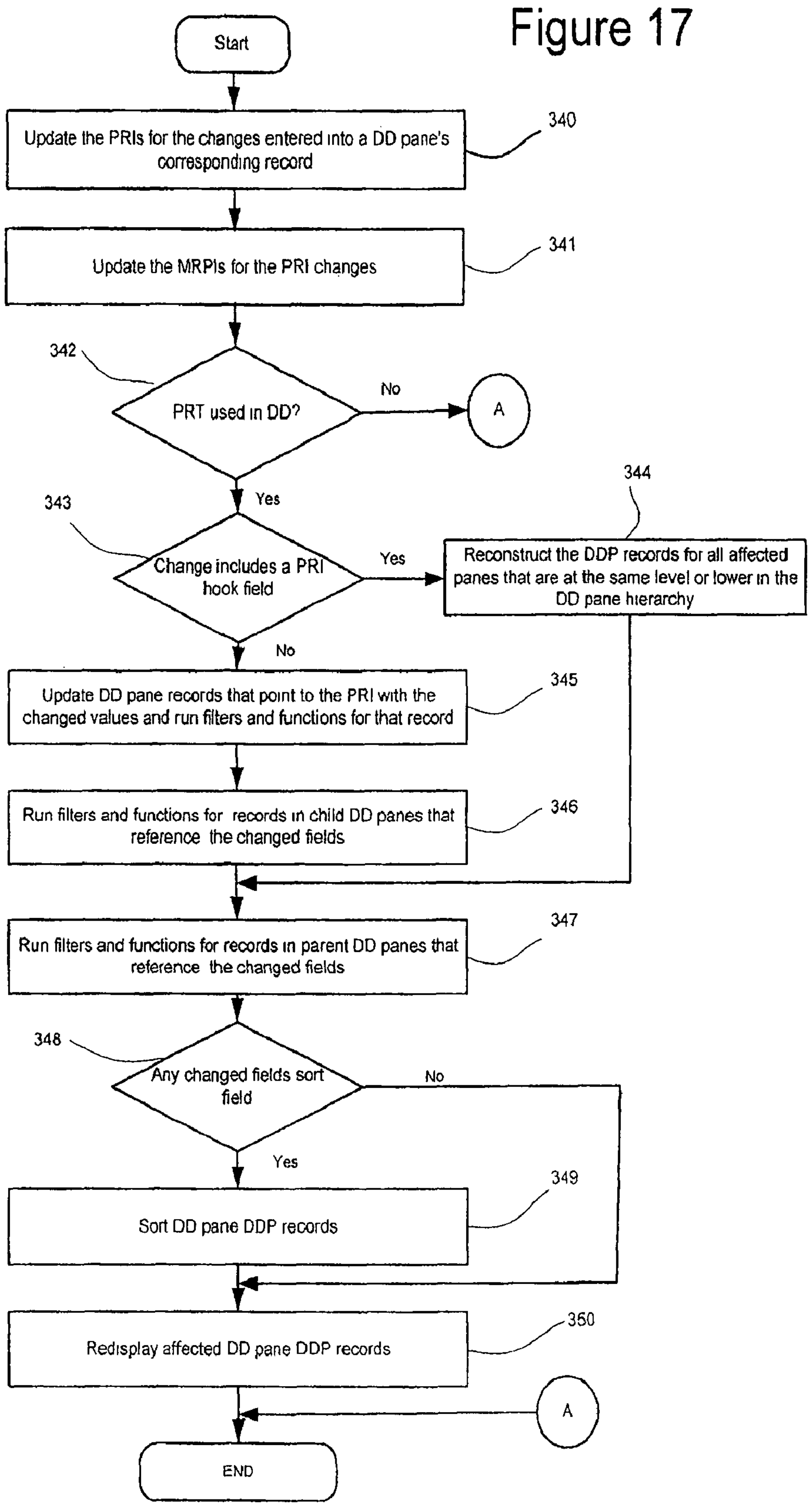

Start
Update the PRIs for the changes entered into a DD pane's corresponding record
340
Update the MRPIs for the PRI changes
341
342
PRT used in DD?
No
A
Yes
343
Change includes a PRI hook field
Yes
344
Reconstruct the DDP records for all affected panes that are at the same level or lower in the DD pane hierarchy
No
Update DD pane records that point to the PRI with the changed values and run filters and functions for that record
345
Run filters and functions for records in child DD panes that reference the changed fields
346
Run filters and functions for records in parent DD panes that reference the changed fields
347
348
Any changed fields sort field
No
Yes
Sort DD pane DDP records
349
Redisplay affected DD pane DDP records
350
A
END

Figure 18A

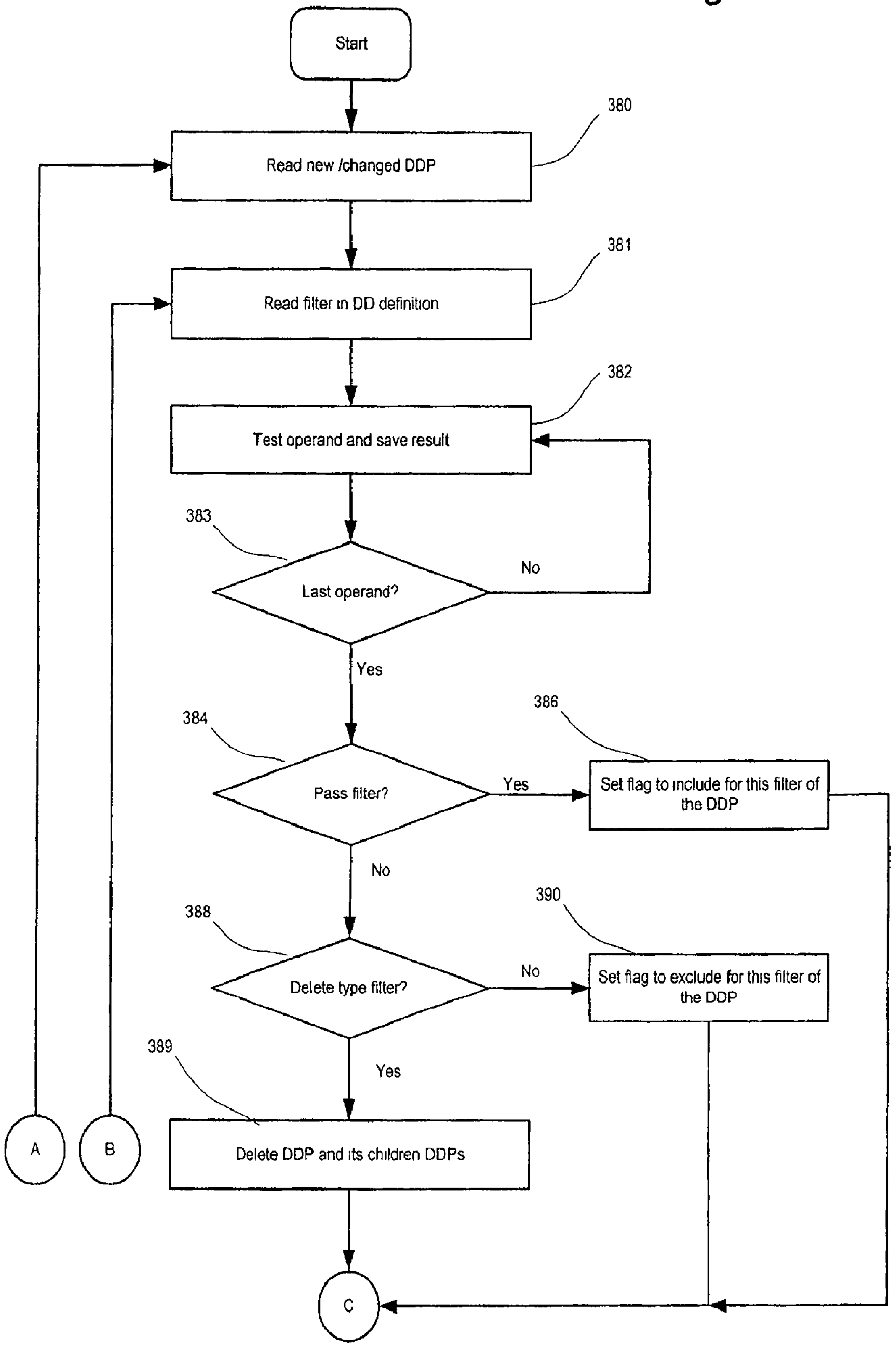
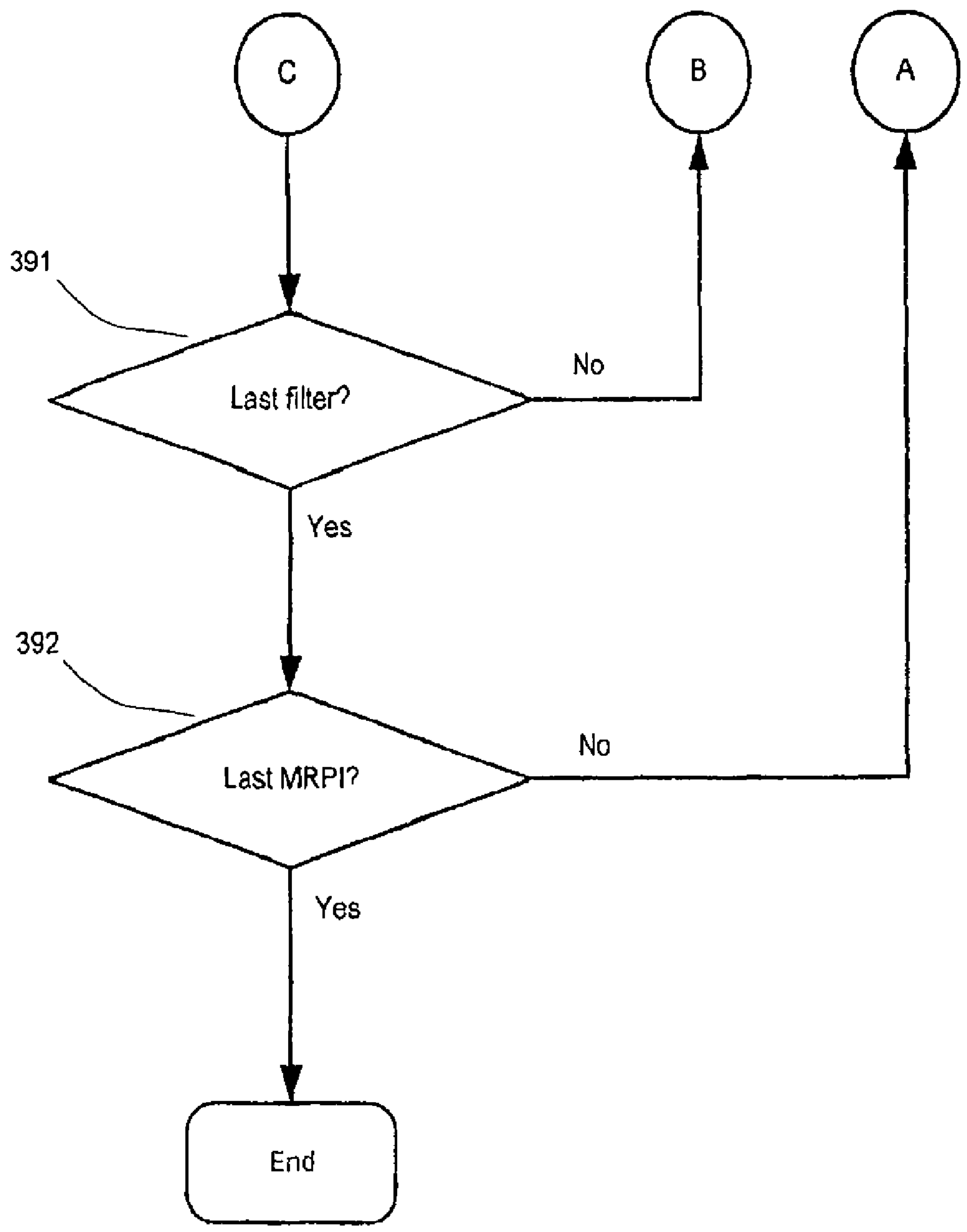

Start
380
Read new /changed DDP
381
Read filter in DD definition
382
Test operand and save result
383
Last operand?
No
Yes
384
Pass filter?
Yes
386
Set flag to include for this filter of the DDP
No
388
Delete type filter?
No
390
Set flag to exclude for this filter of the DDP
Yes
389
Delete DDP and its children DDPs
A
B
C

Figure 18B



SYSTEM AND METHOD FOR NON-PROGRAMMERS TO DYNAMICALLY MANAGE MULTIPLE SETS OF XML DOCUMENT DATA

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 09/976,710, filed Oct. 15, 2001, in the name of Richard VanderDrift, titled "System and Method for Non-Programmers to Dynamically Manage Multiple Sets of XML Document Data," now U.S. Pat. No. 7,117,220, which is hereby incorporated by reference as if fully set forth herein.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to systems and methods for interfacing with and using Extensible Markup Language (XML) documents; still more particularly, the present invention relates to systems and methods that allow the non-programmer to easily modify the display format, functions, and filters operating upon data extracted from XML documents.

2. Description of the Related Art

Companies use XML documents to publish various types of information for use by customers and partners. The type of information in such XML documents is frequently common transactions such as invoices and purchase orders and common reference documents such as customer profiles and price lists. Computer programmers design these XML document formats in a technical manner. People and programs that extract data from corporate databases typically create the XML documents containing actual data.

While XML formats are convenient for the company that creates them, the partners of that company may find them incompatible with their own XML formats, relational database schemes, and message formats and therefore difficult to work with. In many cases, the user is forced to have programmer create a program to merge, filter and transform XML documents into the format they want. Thus, XML documents are very difficult for the businessperson or non-technical user to operate. Therefore, there is a need for a system that both allows the user to view and update XML documents in different formats, and allows the user to manipulate the data and perform actions without programming skills.

SUMMARY OF THE INVENTION

The present invention overcomes the limitations and shortcomings of the prior art with a system and methods for dynamically retrieving, manipulating, updating, creating, and displaying data from sources of Extensible Markup Language (XML) documents comprises a central processing unit, an input device, a program memory, a display device, mass storage, and a network. The program memory comprises system-user entered data definitions and business rules. The system imports XML document data into the system data definitions (an integrated combination of Relational and Object), processes the data using the business rules definitions and exports XML documents. The system can automatically create XML document formats from its data definitions and can automatically create its data definitions from XML document formats; the system-user can also define the mapping between XML document formats and the system data

definitions. The system data definition is the combination of a Relational data model, an Object data model, and an XML data model.

The system has three major data types: primary record types (PRTs), management record types (MRT), and dynamic documents (DD). A PRT is similar to a relational database table; they contain most of the data. A MRT is a grouping of PRTs; they contain pointers to individual PRT records and some calculated data. A DD is a restructuring of a set of MRT instances for analysis and presentation; they contain pointers to the MRT components and some calculated data. The system's data structure is much more sophisticated than that of a relational database or a set of XML documents. Unlike a relational database, the business rules can use the complex data relationships of the MRTs and DDs, and system-users can easily define views of the data that do not conform to the constraints of the relational data model. Unlike a set of XML documents, the system-user can easily merge data from multiple XML document formats. Also the system stores only one instance of duplicate XML components; manipulating the one instance automatically affects all XML documents that include that instance.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram of a preferred embodiment of the system for extracting and dynamically displaying data in accordance with the present invention.

FIG. **2** is a graphical representation illustrating the context in which the system and methods of the present invention operate.

FIG. **3** is a graphical representation of an exemplary embodiment for a management record.

FIGS. **4**A, **4**B, **4**C, and **4**D are a flowchart of an overview of the preferred method for initializing and operating the system in accordance with the methods of present invention.

FIG. **5** is a flowchart of the preferred method for generating management record pointer families.

FIG. **6** is a flowchart of the preferred method for fetching data from an underlying data source and constructing management records.

FIGS. **7**A and **7**B are a flowchart of the preferred method for executing functions for a new set of management records.

FIGS. **8**A and **8**B are a flowchart of the preferred method for executing a filter for any number of management records and their pointer families.

FIGS. **9**A and **9**B are a flowchart of the preferred method for creating a dynamic document pointer for a new set of dynamic documents.

FIG. **10** is a flowchart of the preferred method for updating a management record for a new primary record instance.

FIGS. **11**A, **11**B, and **11**C are flowcharts of the preferred method for updating a management record pointer instance for a changed primary record instance.

FIGS. **12**A and **12**B are a flowchart of the preferred method for executing a function for a changed primary record instance.

FIG. **13** is a flowchart of the preferred method for maintaining a function for a changed management record type or dynamic document.

FIG. **14** is a flowchart of the preferred method for maintaining a filter definition for changed management record type or dynamic document.

FIGS. **15**A and **15**B are a flowchart of the preferred method for executing a function for a changed management record pointer instance.

FIGS. **16**A and **16**B are a flowchart of the preferred method for executing a function for new dynamic document pointers.

FIG. **17** is a flowchart of the preferred method for executing a function for a new or changed set of dynamic document pointers.

FIGS. **18**A and **18**B are a flowchart of the preferred method for executing a filter for a changed dynamic document pointer.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

In accordance with the present invention, a system for dynamically retrieving, manipulating, updating, creating, and displaying data from sources of Extensible Markup Language (XML) documents is shown in FIG. **1**. A central processing unit (CPU) **12** connects with a display and input device **16** and a program memory **18**. The CPU **12** is also coupled to the Internet **33** and an intranet **31** in a conventional manner. XML documents **37** fetched from the Internet **33** and intranets **31** are temporarily stored until they are converted into Primary Record Types (PRTs) **26** and Management Record Types (MRTs) **24**. The system **10** also creates XML documents **37** that it exports to the Internet **33** and intranets **31** in a conventional manner.

The memory **18** also stores a Dynamic Document (DD) **20**, a MRT **24**, pointers for constructing and displaying DDs and MRTs **24**, and functions, filters & sorts **42** along with an operating system. The CPU **12**, under the guidance of instructions received from the program memory **18**, imported XML formats **38**, and from the user through the input device **16**, creates MRTs **24** and DDs **20**, XML documents **37**, and XML formats **38** and displays data on the display device **16**. The methods of the present invention preferably extract data from the Internet **33** and intranets **31**, perform functions and filters on the data, and store the extracted data as PRTs **26** in the program memory **18**. The MRTs **24** are then further processed with other routines in memory **18** to be displayed as DDs **20** that include a user interface to display information on the display **14**. Those skilled in the art will be aware that various equivalent combinations of devices can achieve the same results when used in accordance with the present invention.

Referring now to FIG. **2**, the context in which the system and methods of the present invention operate will be described. As has been noted above, the present invention overcomes the problems associated with presently available tools for non programmers to easily modify the display format, functions, and filters operating upon information extracted from XML documents **37**, In particular, the present invention removes the problems of interfacing with and analyzing data from XML documents **37** by providing DDs **20** and MRTs **24**. A DD **20** is a mechanism for displaying, manipulating, and printing MRTs, and for mapping how changes to the MRTs should update one or more XML documents. The DDs provide user interfaces as well as display and organization rules for displaying the data to the user **36**. In the preferred embodiment, a DD **20** has the form of window on the display device **16** with a hierarchy of display panes. Each pane is used to display one or more or the PRTs that comprise a MRT. The present invention also includes procedures for entering data changes using DDs. As will be described, the process for modifying data with DDs is very simple for the user. A change entered with a DD automatically updates the MRTs to update other related MRTs and updates and create XML documents.

The present invention interfaces with the underlying XML documents by copying the XML data components into normalized data objects referred to as PRTs and organizing the PRTs into recognizable business objects referred to as MRTs **24**. Examples of business objects that are modeled as MRTs with the present invention include, but are not limited to: invoices, bills of material, purchase orders, price books, forecasts, and fund transactions. The present invention advantageously works in conjunction with underlying data sources **38**, **40** to reconstitute data stored therein into a structure recognizable by and easily manipulated by the businessperson. The user can define functions (calculations), filters (selection criteria), sorts, and DDs (display and organization rules) over MRTs.

A MRT is a user-defined collection of PRTs organized into a hierarchy. One and only one of the PRTs uniquely define a node in the hierarchy. A single instance of a PRT results in a single instance of a MRT hierarchy node. A single instance of the PRT assigned to the top hierarchy node results in a single instance of the MRT. An instance of an MRT is a Management Record Pointer Family (MRPF) **90**. In the example of FIG. **3**, the Order Header is the PRT that uniquely defines the MRT. A PRT is where the invention stores the data extracted from XML documents; PRTs are similar to relational database tables. A "hook" **44** refers to the method used for linking or showing relationships between records stored in different PRTs. Such hooks include pointers and foreign keys. A hook typically provides a one to many relationship between a parent record and a child record. As shown in FIG. **3**, the hooks are represented by lines where a single occurrence of a connecting line attaches to the parent, and multiple occurrence of the connecting line attach to child. A hook not only specifies which fields of a PRT point to which fields of another PRT, but also specifies the number of hooks any particular instance of one PRT can and must have with the instances of the other PRT.

It should be understood that PRTs are unlike XML components. First an XML component instances are not shared with other XML document instances. In other words, two XML documents may have identical values in all its elements. Unlike XML components, no two PRTs have identical values in the fields that uniquely identify a PRI. Second an XML component type has at most one parent component type where as a PRT can have multiple parent PRTs. It should be understood that MRTs are different than XML documents. First, a MRT can be comprised of multiple XML documents; for example a MRT can incorporate the data in both an Order XML document, and Customer XML document, and Product XML document. Second unlike an XML document, a MRT does not have any redundant data. For example an Open Orders XML document would contain duplicate customer information for every order for the same customer and duplicate product information on every order line for the same product, A MRT does not actually include the customer and product data but has a pointer to the single instance of data for each customer and each product. MRTs require less storage space than XML documents and when users change the product information and it is immediately reflected in all MRTs that point to the changed product.

MRTs also have significant advantages XML documents elements, and object database composite objects. A system administrator predetermines hierarchies of XML documents and object-oriented databases, typically. The users manually maintain the pointers between the individual records. Family trees (which do not show spouses) are examples of hierarchies. The relationships are rigid and only movement from parent to child and visa versa is permitted. Any new hierarchy is empty until parent and child records are explicitly linked to each other either manually or by writing a custom program to build the links. MRTs, on the other hand, automatically populate a hierarchy of PRTs using PRT hooks **81** according to definitions set by the user.

Also, unlike in an XML document component hierarchy where relationships are rigid, a parent PRT can be the child node in a MRT hierarchy. For example in FIG. **3**, customer order header is typically a child component to a customer component but with the present invention, the user can define a customer order MRT where the customer order header is the parent. In this example, the customer order header is the top node for this MRT while the customer is a single occurrence child.

FIG. **3** illustrates an example of the pointer structure of the present invention that is used with the MRT **24**. The pointer structure is preferably used to improve the speed for processing filters, sorts and functions. As has been noted above, one PRT **52**, in this case order header, is used to uniquely identify the MRT **24**. Each PRT **26** is linked either directly or indirectly by hooks **44** to the order header PRT. The present invention also produces pointer families **46-49** to divide the PRTs **26** in the MRT **24** into groups. Each of the management record pointer families (MRPF) has a lead PRT **50** that directly or indirectly through another lead PRT **50** has a many to one relationship with the unique identifying PRT **24**. The PRTs that have a one to many relationship **44** with a lead PRT **50** or the one PRT **52** are included in the PRT pointer family **46-49**. The example of FIG. **3** will be used below to illustrate the operations performed by the present invention on MRTs **24**.

Referring now to FIG. **4**, an overview of the preferred method of the present invention is described. The preferred method begins with a series of steps in which the user inputs defining information described in FIG. **4**A. In step **80**, the user defines or imports the XML format. In step **81** the invention creates PRTs by identifying the XML format components that have at least one child component. When the PRT already exists, the user maps the XML format components to the data elements of the already existing PRT.

In step **82**, the invention creates hooks between every PRT that it creates and the XML component and the PRT it creates for its immediate parent XML component. The user can also define hook definitions between two PRTs by specifying the fields in the child PRT that corresponds to the unique identifying fields of the parent PRT. Next in step the invention creates the MRT definition and its Management Record Pointer Family (MRPF) as described in FIG. **5**. To manually create a MRT, the user selects a first PRT. After the user selects the PRT, the system presents the user with a list of all PRTs that have a hook with the first PRT or any PRTs in the list. The user then selects any of the listed PRT for inclusion in the MRT. After the user has completed selection of PRTs, the user specifies which one of the PRTs selected is the unique identifier for this MRT.

Next, in step **83**, the invention creates a DD for the XML format as defined in FIG. **5**B. In step **84**, the user can manually enter additional DDs. The user can now enter definitions for the rules that manipulate the data in the MRTs and DDs. Enter definitions for functions in step **85**, for filters in step for **86**, and for sorts in step **87**. The methods used for defining these definitions are similar to those typically used in the art.

In FIG. **4**B, an overview of the preferred method for managing the import and processing of new XML documents is described. In step **89**, a user imports an XML document of a format previously imported into the invention. In step **90**, the invention creates the PRIs and Management Record Pointer Instances (MRPIs) as described in FIG. **6** below. The preferred method, in step **91**, next executes MRT pre-function filters on the fetched data, as discussed below with reference to FIG. **8**. Then in step **92**, the MRT functions are executed using the fetched and filtered data as described in FIG. **7** below. Next in step **93**, MRT post-function filters are executed. These filters are executed with a similar process used in step **91**. Now that the data from the data sources has been retrieved, the preferred method creates dynamic document pointers (DDP) for displaying the data in step **94** (See FIG. **9** and discussion below). As with MRTs, pre-function filters (See FIG. **18** and discussion below), functions (See FIG. **16** and discussion below), post-function filters, and sorts are executed in steps **95**, **96**, **97**, and **98**, respectively. Then in step **98**, the dynamic document pointer's (DDP's) calculated fields, MRPF's calculated fields, and the PRIs are organized into panes and records for display in a window or for writing of XML document for each DD instance.

In FIG. **4**C, an overview of the preferred method for managing the processing of data changes entered by users is described. The user can now enter revisions to update the data using the DD displays in step **100**. In step **101**, the method first determines whether the change includes a new PRI record because the user entered new unique identifier values for the affected PRT. If change is not a new PRI, step **102** updates the existing affected PRI. If a new PRI is required step **103** created the new PRI, and step **104** determines if the PRIs PRT is the lead PRT for a Management Record Pointer Family. If it is not a lead PRT, step **105** updates the appropriate MPRI to now include the new PRI. While if it is a new lead PRT, step **106** creates the new MRPI. Next, in step **107**, the present invention executes the functions and filters for the revision. If any of the functions changes data values, step **108** sends those revisions to step **101** to be processed in the same manner as user entered revisions. If the functions produced no data revisions, step **109** follows where the DDs **20** are updated to reflect the revision. Then in step **110**, the method updates DDP records for display in a window or writing of an XML document.

In FIG. **4**D, an overview of the preferred method for managing user changes to processing rules is described. In step **111**, the user enters a change to one of the rules that manage the data. In step **112** the preferred method tests whether the revision is a function revision. If not, the process continues to step **114**. However, if the revision is a function revision, the function is executed with the revision in step **113**, and as described below with reference to FIG. **13**. In step **114**, the preferred method determines whether the revision is a filter revision. If not, the process continues to step **116**. However, if the revision is a filter revision, the filter is reexecuted using the revision in step **115**, and as described below with reference to FIG. **14**. Then in step **116**, the preferred method test whether the revision is a sort revision. If not, the method continues to step **118**. However, if the revision is a sort revision, the sort is executed in step **117**. In step **118**, the preferred method tests if processing the revision as described above resulted in revisions to data. If there are, the method loops to step **101**. If the revision did not generate other revisions, the method moves to step **119** where it updates the display of the DDs to reflect changes to the sequence of data and the inclusion or omission of data affected by the changes to the filter criteria.

In FIG. **5**, the preferred method for generating MRTs and their and their corresponding Management Record Pointer Families (MRPFs) is described. The process begins in step **120** where the user imports or enters an XML format. In step **121** where the invention identifies all the PRTs that comprise the XML document format. For every component within the XML document format that contains one or more components, the invention identifies a potential PRT. In step **122**, the user indicates if the PRT already exists. If it does exist, in step **124** the user maps the field level components in the XML document to the fields in an existing PRT. The method then proceeds to step **129**. If it does not exist the method automatically creates a new PRT. Step **126** checks the PRTs to determine if it is a multiple occurrence component: a multiple occurrence component can have more than one instance in a single XML document. If it is a multiple occurrence PRT, step **127**, it creates a new MRPF with that PRT as its lead PRT (item **50** in FIG. **3**). If it is a single occurrence PRT, step **128**, the invention assigns the PRT to the MRPF where its parent PRT is the lead PRT. In step **129**, the method determines if the XML format has any remaining PRTs to process. If any remain the method proceeds to step **121** to process the next PRT.

In FIG. **6**, the preferred method for copying the data in XML documents into the invention's DDs, MRTs, and PRTs. This process begins when the method receives a new XML document the user queried or some other program sent to the invention. In step **130**, the XML document is read. In step **131** the components within the XML document that comprise one of its PRIs are read. Step **132** determines if the read components are for a new or existing PRI. If the PRI already exists, step **133**, updates the existing PRI to reflect the new data values and step **134** updates the MRPF instance records (MRPIs) that use the changed PRI as described in FIG. **11**. If the XML document includes a new PRI, step **135** creates it and step **136** updates the MRPIs that use the new PRI as described in FIG. **10**. Step **137** determines if any additional PRIs exist within the XML document. If any remain, the invention returns to step **131** to process the next PRI. When all the PRIs are processed, step **138** recreates the DDs as described in FIG. **11**.

Referring now to FIGS. **7**A and **7**B, the preferred method for executing functions will be described. A function is one or more mathematical, financial, and statistical calculations performed using the fields of the MRT's PRTs. Examples of functions include: add, subtract, multiply, divide, round, test, join, summarize, generate a random number, log, remainder, and calculate present value. Examples of "group by functions" include: any occurrence, first occurrence, last occurrence, sum, average, count, maximum, minimum, standard deviation, variance, and net present value. The present invention is particularly advantageous because any combination of PRT fields and any MRPF calculated fields can be used in a function. If the field being used is not in the pointer family or one of the fore parents of the pointer family to which the results are assigned, the present invention requests that the user enter the "group by function" it should perform on that field prior to using it in the calculation. For example, if a user wishes to calculate an order discount by multiplying the order line dollar amounts by the order header discount and then store the results in the order header, the user would specify the "sum" group by function for the order line dollar amounts because order lines are children not fore parents of the order header where the result is stored.

The user specifies if particular functions should be executed prior to or after the filters are executed. If the user wants, for example, to not display tax order lines but wants to include the tax amount from those lines in the total order amount, the function to calculate total order amount from the order lines occurs prior to filtering out the tax order lines. If the user wants, for example, to not display tax order lines and does want to include the tax amount from those lines in the total order amount, the function is executed after filtering out the tax order lines.

The present invention attempts to minimize the time it takes to run the functions for a new set of management record instances (MRIs) by running each function only once and by reading each PRI as few times as necessary. Because functions can include the results (calculated fields) of other functions, the present invention "restates" functions to improve calculation speed. The present invention first ensures that all functions are restated as only PRT fields and group by functions of PRT fields. Restatement eliminates (except for group by functions) one function being dependent upon another function because that function uses the result of the other function. Restatement occurs for each function when the user first defines (enters or maintains) it or one of its component functions. Besides replacing calculated fields with the fields from which they are calculated, the present invention also determines in which pass a specific function should be processed. For a particular MRI, the present invention must make multiple passes when a group by field from one level in the MRPF hierarchy is used in a function in another level in the MRPF hierarchy and the result of that function is used in another function in the original group by function hierarchy level. For each function, the present invention checks to see if that function is comprised of any function which uses a group by fields from a different hierarchy or uses a calculated field from a hierarchy level higher than the current level. If either of the above two conditions exist, the present invention adds one to the calculation pass sequence number. The present invention then runs the same routine on the subfunctions that meet the test conditions. The present invention continues this process until it has no more sub-functions to test. As a result of this process, each function has a pass sequence number.

As shown in FIGS. **7**A and **7**B, the method starts with step **150** in which the MRT definitions are read. The present invention processes each MRI separately. Then, in step **151**, a MRI is read and the pass sequence number is set equal to zero. In step **152**, the method reads the lowest unprocessed MRPF level for this pass. First, the method executes for each MRPI all the functions with a pass sequence number of zero at the same time. It starts with the MRPFs that are lowest in the hierarchy and works its way up. In step **153**, the method reads the MRPF's functions. Then in step **154**, the method reads other MRPF's group by functions that use this level. Group by functions are executed with the MRPF they summarize, not the MRPF where the result is stored. The MRPIs of the MRPF are then read in step **155**. Then in step **156**, the functions for this MRPF are executed and added to the MRPI. The group by accumulators is then updated. Group by accumulators store not only the results of the group by calculation, but also enough information to recalculate the amount without rereading all the MRPIs if one of the component MRPI changes. For example, a "mean" group by accumulator includes not only the means but also the total number of MRPIs. Next in step **158**, the system determines whether the MRPI being used to execute the functions is the last MRPI for this MRPF. If not, the method returns to step **155**, otherwise the process continues in step **159**. In step **159**, the group by results is added to the parent MRPI. Then in step **160**, the method test whether this is the last MRPF for this MRT. If not, the process loops to step **152** to process any unprocessed MRPFs, otherwise the process continues in step **161**. In step **161**, the method determines if this is the last pass. The higher the pass sequence number that a group by function has the latter it gets processed. The sequence number is based on the nesting of the group by function. If it is not the last pass, then 1 is added to the pass sequence number in step **162** and the method returns to step **152** for further processing. After each pass of all the MRPIs, the method executes the functions with the next highest pass sequence number until all functions are executed. However, if it is the last pass, the method continues in step **163** where the process tests whether this is the last MRI to perform functions for. If not, the process returns to step **151**, otherwise the execution of the functions for the MRT is complete.

The present invention also provides for manipulation of the data using filters. The filters of the present invention are advantageous because the user does not need to join the underlying tables together in his/her select statement. Users can select a subset of all possible MRTs and a subset of the MRPFs that comprise the selected MRTs. Section criteria are applied against any PRT or calculated field in the MRT. Where there could be multiple occurrences of the field in a MRT (such as quantities ordered on one customer order), the user must also specify a group by filter just as with functions. The present invention has the two special group by filters "any" and "all." The other selection criteria are: equal to, not equal to, greater than, less than, like, and exists in dynamic document X. Filters can be comprised of multiple selection criteria. The criteria can be nested and include AND/OR conditions. An example of a filter is give me all MRTs where the customer is in California, and the total of the order line amounts is greater than $10,000, and any of the Salespersons are in territory one, or the order is on hold.

Any number of filters for a MRT or its MRPFs can be active at any time. The user defines as many filters as he/she wishes and then activates and deactivates them whenever he/she wants. Filters are executed either when the MRIs are fetched by the production data source or after they are stored in memory **18**. The user specifies which filters should be part of the fetch. Because of performance concerns, fetches with group by functions cannot be used for fetches. The user can also indicate if the filter is for just temporarily hiding the data or for deleting the data. If a parent MRPI is filtered out, so are its children MRPIs. Filters for MRTs are handled exactly like filters on the top most MRPF in the hierarchy.

FIGS. **8**A and **8**B illustrate the preferred process for executing filters. The process begins by reading any new or changed MRPI in step **170**. Then a filter from the MRT definition is read in step **171**. Next, in step **172**, an operand is tested, and the result is saved. Since all filters operate on fields in the MRPF or on fields which have been grouped by a function into the MRPF, each MRPI can be fully tested to see if it should be filtered out by reading only the MRPI's calculated fields and its PRT's PRI field values. For improved processing efficiency, the present invention executes all of a MRPI's filter tests one after the other. The operation tests are simple Boolean tests to see if the field's value equals the value stored in the filter, or stored in the specified variable, or is in the list (Dynamic Document) specified. The present invention stores the result (true or false) of each operation. The method then determines if this operand is the last operand to test in step **173**. If not, the process returns to step **172** to test the next operand. If all the operands have been tested, then the process continues to step **174**. In the step **174**, the method looks at the results of each operand to determine if the entire filter results in a pass or fail. If the MRPI passed the filter, the method proceeds to step **177** where the method appends to the MRPI a flag for each filter indicating if the filter includes that particular MRPI. If the MRPI fails the filter, the method jumps to step **178** to evaluate the filter type. In step **178**, further tests are performed to determine if the filter is a delete type. If the filter a delete type (i.e., MRPIs that are filtered out are deleted instead of not being displayed), the MRPI and its children MRPIs are immediately deleted in step **179** so no other filter need process them. Any MRPI that has any parent MRPI that is excluded is itself excluded. If the filter is not a delete type,

then the flag is set to exclude in step **180** for this filter in the current MRPI's MRPF filter affects list. Any MRPI that is excluded by any active filter is not displayed in the currently open DDs **20**. Next, step **181** determines whether there are additional filters to be processed. If so the method loops to **171**, otherwise the method tests whether this is the last MRPI to be processed in step **182**. If there are more MRPIs to process, the method returns to step **170**, otherwise, the process is complete.

As has been noted above, Dynamic Documents are used to display XML document data to the user. Essentially, DDs are a rearranged and reformatted MRT. A DD is a window on the display device **14** comprised of a hierarchy of display panes. Each pane displays one or more of the MRT's PRTs and calculated fields. The user can define functions, sorts, and filters for each DD. A DD is also a tool for users to update a PRI and thereby the MRs and DDs that reference the PRT. Each DD corresponds to one MRT and each DD pane corresponds to one or more of the PRTs used by its MRT. The advantage of using DDs to create multiple data view and update transactions is that the data relationships can be radically restructured from that of the MRT. Child records can become parents, records can share fields, calculated fields can be created, and sets of records can be summarized into single records and values.

The DDs are created by the user based on the types of information that the user wants to view and update. The user selects which of the PRTs in the MRT to include in the dynamic document pointer (DDP). For user viewing or update, the invention creates DDP records by accessing the field values in its underlying PRT's PRIs and its underlying MRPI's calculated fields. Any PRT in the MRT can be used in the DDP and can be used more than once in a single DD. While their shared hook predefines the relationship between any two PRTs in a MRT, the user defines the relationship between any two PRTs in a DD. By putting a PRT in a parent hierarchy pane, the user is making that PRT the parent of all the PRTs in the children panes even if the PRTs have a different relationship in the MRT. This capability allows the user to represent the data in virtually anyway they want even though that representation is not supported by the production data source in which the data is stored. For example, a customer order MRT that has its Items PRT hooked to its Order Lines PRT which in turn is hooked to its Order Header PRT and also has Salespersons separately hooked to its Order Header PRT, as described above with reference to FIG. **3**, can have a DD where the Item PRT is in the top level pane and the Salesperson is in a child pane. In this example, the Item has become the parent of Salesperson. The DD displays in the top pane any Item used in any Customer Order MRT, and displays in the child pane all the Salespersons that sold that Item on any Customer Order.

When the user places a PRT in a DDP, the user gains access not only to the PRT's fields in that pane and any of its child panes, but also access to all the calculated field of the PRT's MRPF. These calculated fields are comprised of fields of the selected PRT and also any field from any other PRT in the MRT. In the above example of the Items pane, the user could display the total amount ordered on all orders for each item even though the DD does not include the order lines or order header PRTs which are required for this calculation.

The user creates the DD Pane definition by entering the pane's name, its position in the pane hierarchy and then by selecting as many of the PRTs of the MRT that are to appear in the pane. The system then automatically joins the PRT's MRPIs together to create the DDPs. These DDPs are the DD equivalent of MRT's MRPIs. Each DDP corresponds to a single pane display row and can roll up into display subtotal rows.

The user specifies how to update production data sources (other than the PRTs) by defining as many separated transactions types as desired. Then the system, for any single update to the DD, automatically creates Production Data source Update Transactions Instances (UTs) and posts them to the appropriate data source. Each Production Data Source Update Transaction Type (PDUTT) can update as many PRTs as the user wishes; the only restriction is that they all be in the same instance of a production data source. A DD's PDUTTs are similar to its pane attributes and report attributes in that it formats the field into an output medium. One primary difference is that a PDUTT does not always request the current value; it can also get the amount a value has changed by as a result of a transaction, or a literal amount stored in the PDUTT. Also, a PDUTT is different in that its instances (UTs) are only created when the DDs underlying MRIs are changed. The user can have all MRI changes result in UTs or can limit them to only changes entered through the DD of the PDUTT, or only when the DD is active (i.e. opened by the user).

Referring now to FIGS. **9**A and **9**B, the preferred method for creating DDPs is described. First, the DD **20** is read in step **190**. Then the highest hierarchy level pane definition not yet processed is read in step **191**. In step **192**, the pane's PRT and MRPF are read. Next, the method tests whether the MRPF is already used in an existing pane in step **193**. If so, the method jumps to step **196** and avoids having to initialize the pane. On the other hand, if the pane does not exist, it must be created. The method creates the pane in steps **194** and **195**. In step **194**, the method runs the pre-join filters on the MRPF's MRPIs. In step **195**, the method joins the MRPIs to previously selected MRPI's for this pane, and the one from the parent pane. The panes are preferably joined on MRT identification and parent MRPF ID fields. The method then continues in step **196**. In step **196**, the method determines if this is the last PRT to be processed. If not, the process returns to step **192** and reads other PRTs. Otherwise, the method continues in step **197**. In step **197**, the method runs all post join filters. Then in step **198**, the method tests whether any child panes for this PRT exist. If there are child panes, the method saves a copy of the joined MRPI for each child pane and continues directly to step **200**. If there are no child panes the method proceeds directly to step **200**. In step **200**, the method determines if this pane or its parent panes include lead PRT for all its MRPFs. If lead PRTs are included, the method executes steps **201** and **202**. In step **201**, the system summarized the joined MRPI's by identification of the PRTs in this and the parent panes. If all the panes include lead PRTs for each MRPF, the summarization step **201** would have no effect; that is why it is shipped. The system in step **202** then runs all post summarize filters, and moves to step **203**. If lead pointers are not included, the method moves directly to step **203** and determines whether this is the last pane to modify. If not, the method loops to step **191**, otherwise the process ends.

FIG. **10** illustrates the preferred method for updating a MRT for a new PRI. The method starts by reading the new PRI in step **210**. Then in step **211**, the PRT definition and the where used list of this PRI are read. Next in step **212**, the definition of the MRT listed in the where used list of step **211** is read. Next, the method determines if the PRT is a lead PRT of a MRPF in step **213**. If it is a lead PRT, the method continues in step **214** where a MRPI is created. Then in step **215**, the function and filters for the MRPI are executed. If it determined not to be a lead PRT in step **213**, then the MRPI of the MRPF is read in step **218**. Then in step **219**, the method tests if the PRI's hook field is in an MRPI. It will rarely be true because this means the PRI was then referenced before it was created. If so, the PRI pointer is added to the MRPI in step **220** and then method proceeds to step **221**. If the PRI's hook field is not a MRPI, the method proceeds directly to step **221** where the method determine if this is the last MRPI to process. If there are additional MRPIs, the method returns to step **218** otherwise the method continues to step **216**. In step **216**, the method tests whether there are additional MRTs to process. If there are, the method jumps to step **212**. If not, the method test for additional PRI to process in step **21**. For any more PRI, the method returns to step **211**, or else the process is completed.

Referring now to FIGS. **11**A, **11**B, and **11**C, the preferred method for updating a MRT for a changed PRI is described. Similar to the method of FIG. **10**, the process begins by reading the changed PRI in step **230**, reading the PRT definition and the where used list of this PRI in step **231**, and reading the definition of the MRT listed in where used list in step **232**. The method next tests whether this a lead PRT for a MRPF in step **234**. If the PRT is a lead PRT for a MRPF, the method continues with step **244** of FIG. **11**C. In step **244**, the process determines if a key field was changed. If a key field was changed, the method executes step **245**, **246** and **247**, to respectively find the old MRPI, remove the old MRPI, and create a new MRPI by executing the new PRI routine of FIG. **17**A for this MRT. However, if a key field was not changed, the method finds the old MRPI in step **248**, changes the MRPI single occurrence pointer for the changed hook fields in step **249**, and then runs the functions and filter for the changed PRIs and MRPIs. After competition of either branch, the method returns to step **241** of FIG. **11**B.

Referring back to **11**A, if the PRT is not a lead PRT for a MRPF, the method continues in step **235** by reading the lead PRIs for the MRPF. Then in step **236**, the method compares the old hook fields values to determine if they match. If there is a match, the PRI is changed by removing the pointer in the MRPI in step **237** before proceeding to step **238**. In step **238**, the method tests if the new hook values match. If there is no match the method jumps to step **241**. If there is a match, the PRI is changed by creating new pointer in the MRPI in step **239**. Then the method runs the functions and filters for the changed PRIs and MRPIs in step **240**. Then the method test whether the current process involves the last PRT, the last MRT or the last changed PRI in steps **241**, **242**, and **243**, respectively. If this is not the last PRT of the last MRT for the last changed PRI, then the method loops to the appropriate step (i.e., steps **235**, **231** and **230**) for further processing.

The preferred method for executing a function for a changed PRI is shown in FIGS. **12**A and **12**B. The present invention handles PRT fields that are used in a group by function or used in the function of a child MRPF especially for recalculation purposes. Whenever one of these PRT's fields change, present invention not only recalculates the functions for its own MRPIs but also recalculates the group by function value and the other functions in which it is used. In other words, present invention treats these fields as calculated fields by finding where they are used and making sure that the additional appropriate recalculations take place. The present invention does this by keeping pointers to the group by functions and functions of the other MRPFs that use the field.

The preferred method begins by reading the PRI and the PRT definition in steps **260** and **261**, respectively. Then in step **262**, the function using the PRI is read. Next in step **263**, the MRT's MRPF for the function is read. Whenever a PRT's PRI changes, the present invention finds the MRPFs that use that

PRT and tests whether any of its functions use the changed fields. In step **264**, the method determines if the PRT is a lead PRT of the MRPF or used in a group by function. If so, the method continues in step **269** by reading the MRPI to which the PRI points. In each MRPI, the present invention stores the MRPI for each MRPF parent. Each parent MRPI that has group by functions using any of the changed fields has its group by value recalculated. Recalculation does not require reprocessing of all the records that are included in the group. The present invention stores enough information about each group by field to recalculate the correct balance for the before and after image of the changed field. For example, for the average field, present invention also stores the number of values used as well as the actual average. New averages are calculated by multiplying the number of values times the average then subtracting the old value and adding the new value and then dividing by the stored number of values. Then the function is executed in step **270**. There functions are executed in a conventional manner. The process is similar to that used in spreadsheets and third generation languages. In step **271**, the functions for any changed MRPI are executed, after which the method jumps to step **268**. However, if the PRT is not a lead PRT of a MRPF or in a group by function, the method proceeds to step **265** where the MRPI is read. Next, in step **266**, the method tests whether the MRPI points to a PRI. Next, the present invention checks to see it any of the calculated fields that the present invention just updated are used in other group by functions. If so, it recalculates the group by value in the appropriate parent MRPF's MRPI. The present invention continues this loop of cascading group by executions until the set of calculated fields that are recalculated have no impact on any other function because those group by fields are not used in any other function. If it does point to a PRI, the function is executed in step **272**, and the functions for any changed MRPI are executed in step **273**. The method then continues in step **267** or arrived at step **267** directly from step **266**. In step **267**, the method tests whether there are any other MRPI for the changed PRI. If there are additional MRPIs, the method returns to step **265** to read another MRPI and process it as has been described above. If there are no more MRPIs, the method moves to step **268** and tests whether this is the last function for the modified PRI. If not, the method returns to step **262** to retrieve and process the next function. Once all the functions have been processed the present method is complete.

Generally functions are executed whenever the user accepts some changes made to a pane row. The user has the option of deferring the execution of the affected functions until he/she wishes. Deferring changes can speed up entry of changes. The present invention knows which other functions to run because whenever a function is defined or maintained, the present invention adds a pointer to the Where Used Pointers of the PRT Fields Definition and the Where Used Pointers of the Function Definition.

FIG. **13** illustrates the preferred method for maintaining a function and its corresponding calculated fields in MRPIs and DDPs. The process begins by accepting user changes to the function in step **280**. Then the method replaces the calculated fields used in the function with its function. Next, in step **282** the method updates the PRTs used in the function to point to the function. Then in step **283**, the MRPF or the DDP targeted to point to the function are updated. In step **284** the MRPI, pane row for the MRPI, or the DDP is read. Finally, the function is run in step **285**. Then the method tests for other MRPI or PRTs affected by the function change and returns to step **284** to process them. Once all the MRPIs and PRT have been processed, this method ends.

FIG. **14** illustrates the preferred method for executing a filter if the filter has been modified. The method starts by accepting the user's changes to the filter in step **290**. Then in step **291**, the method updates the MRT definition or DD **20** pane definition to point to the filter. Next, the method reads a MRPF, a pane row, or a MRPI for filters pane in step **292**. The filter is then executed with the changes in step **293**. The method then test whether there are other MRPI or PRT affected by the filter changes and then returns to step **292** to process them if they are present.

Referring now to FIGS. **15**A and **15**B, the preferred method for executing a function for a change to the MRPI, as used in FIG. **17** below, is described. In step **300**, the images of the MRPIs before and after the changes to the MRPI are read. The present method preferably saves images of the MRPI whenever anything is changed. These images are saved until the changes have been processed. In step **301**, the MRPF of the changed MRPI is read. Then in step **302**, the calculated field of the before and after images are compared. In step **303**, the method tests whether the value for each calculated image has changed. If there is no change, the method repeats step **302** to get the next calculated field. However, if there is a change, the method moves to step **304**. In step **304**, the function(s) that use this calculated field are retrieved. In step **305**, the method tests whether any of the functions using this calculated field are group by functions. If a group by function is involved, the method first reads the MRPI's parent MRPI where the calculated amount is stored in step **307**. Then in step **308**, the group by value is recalculated. If a group by function is not involved, the method recalculates the function for this MRPI in step **306**. Next in step **309**, the method tests whether this is the last function affected by the change. If more functions are affected, the method returns to step **304** to process those other functions. Otherwise, the method continues to step **310** to determine if this is the last calculated field that has been modified. If there are more calculated fields to process the method returns to step **302**. If not the process is complete and all the values are function value.

FIGS. **16**A and **16**B illustrate a preferred method for executing a filter for a new or changed set of DDPs. DD functions work almost identically to MRT functions. The calculation logic is the same except DDPs correspond to MRPIs. Panes correspond to MRPFs, and top pane DDPs correspond to MRIs. MRT functions are always executed prior to DD functions. Also, if a pane does not include in itself or its parents, the lead PRT for its own lowest level MRPFs, it must be summarized. Summarization is just the process of grouping then the pane and its parent panes. Calculated fields from the pane's MRPFs must be grouped by one of the standard group by operands (See Appendix A). The user specifies the group by operand when he/she defines the DD.

The method starts in step **320** with the DD definition being read. The present invention processes each dynamic document instance (DDI) separately beginning with the lowest level panes in the pane hierarchy and working upward.

In step **231**, the top-level pane DDI is read and the variable PASS LEVEL is set equal to zero. In step **322**, the method reads the lowest unprocessed pane hierarchy level for this pass. In step **323**, the method reads the pane's functions. Then in step **324**, the method reads other pane's group by function (s) that use this level. Group by functions are executed with the pane they summarize not the pane where the result is stored. The DDPs for this pane are then read in step **325**. Then in step **326**, the function for this pane are executed. The group by accumulators are then updated in step **327**. Next in step **328**, the system determines whether the DDP being used to execute the functions is the last DDP for this pane. If not, the method returns to step **325**, otherwise the process continues in step **329**. In step **329**, the group by accumulator values are added to the DDI. Then in step **330**, the method test whether this is the last pane for this DD **20**. If not, the process loops to step **322** to process any unprocessed panes, otherwise the process continues in step **331**. In step **331**, the method determines if this is the last pass. If it is not the last pass, then 1 is added to the PASS LEVEL in step **332** and the method returns to step **322** for further processing. After each pass of all the DDI, the method executes the functions with the next highest pass sequence number until all functions are executed. However, if it is the last pass, the method continues in step **332** where the process tests whether this is the last top DDI to perform functions for. If not, the process returns to step **321**, otherwise the execution of the functions for the DD is complete.

All changes to any data is entered by the user through DDs or fetches from a production data source. All changes can affect multiple DDs and MRTs. For example, if the user changes a customer's discount percentage and multiple MRTs use that field in their calculations, the present invention must update many MRPIs and DDPs for that one change. Therefore, when the user enters a change, the present invention first updates the affected PRT and then the MRPIs and finally the DDPs that use that PRT. The updates to the MRPIs have been described above with reference to FIGS. **4** and **5**.

FIG. **17** illustrates the preferred method for updating a DD pane's dynamic documents pointers (DDPs) and the displayed records for data changes. Users enter data changes through any of a MR's DDs. Newly imported XML documents also create data changes. The preferred method identifies data changes and ensures that all affected DDP records are either updated with the new values or recreated. (The method for filtering and displaying DD pane data is described in FIG. **18**.) In step **340**, the method maintains PRIs for data enter through a DD or imported as XML documents. The changed values can be changes to existing PRI field values including field values that are also hooks to other PRIs, as well as changes that are also new PRIs. In step **341**, the method maintains the MPRIs for the changes PRIs as described in FIG. **10** for new PRIs and FIG. **11** for existing PRIs.

Next the method checks every DD that is currently activated to determine the changes, if any to make to its DDP and the displayed records. In step **342**, the method tests whether the PRT is used by the DD; if not used no further processing is done on that DD. If the DD does use the PRT, step **343** checks to see if any hook fields were changed. If so step **344** deletes all the DDP records that references the changed PRT. The method also deletes all DDP records in DD panes lower in the DD pane hierarchy than that of the affected DDP. Step **344** then it recreates the DDP records as described in FIG. **9** and proceeds to step **347**. When a hook field was not changed, step **345** updates the DDP record field values with the new PRI field values and runs the DD filters and functions on the changed record. Then in step **346**, the method runs the filters and functions for all records in DD panes that are lower in the DD pane hierarchy and also reference the changed DDP record. In step **347**, the method runs the filters and functions for all records that are higher in the DD pane hierarchy and reference any DDP record changed by steps **344**, **345**, or **346**. When step **348** determines the method changed any field value in a DDP record used by the sort rules, it sorts the DD pane in step **349**. Finally the method redisplays all DDP records that it modified or resorted.

As an alternate method, steps that would determine which DDP records were affected by the change in a hook value

could replace step **344**. This alternate method would not reconstruct all the DDP records, but would modify, delete, and insert only the records required by the field value changes. This method could be more efficient when the ratio of changed DDP records to the total number of records is very low.

FIGS. **18**A and **18**B illustrate the preferred process for executing filters when a dynamic document pointer is created or revised. DDs have three sets of filters: filters for determining what data to display on the screen, filters for determining what data to print on a report, and filters to determine which changes to send to targeted production data sources. All three types of DD filters work almost identically to MRT filters. The calculation logic is the same except DDPs correspond to MRPIs, Panes correspond to MRPFs. MRT filters are always executed prior to DD filters. Unlike MRT filters, DD filters are not all executed at the same time for a single DDP. When first constructing a DD's DDPs to minimize the number of MRPFs processed in arriving at the pointers for a pane, the present invention categorizes filters into four categories and executes them at different times during the creation and updating of DDPs: 1) Prejoin filters are executed on a pane's MRPF's MRPIs prior to joining them with the other MRPIs for the pane. Filters that have operands on only the fields in the PRTs for the MRPF are in this category. Also filters which meet the first criteria and also use a calculated field from the MRPF and lead PRT for the MRPF is in the current pane or any parent pane are in this category; 2) Post join filters are executed after all of a pane's MRPIs are joined together with its parent pane's MRPIs. Filters that meet the above criteria but used fields from more than one MRPF are in this criteria; 3) Post summarize filters are executed after the joined MRPIs are summarized into Pane Pointers. Filters which do not use calculated fields from DD functions are not in either of the above two categories; and 4) Post function filters are executed after the select functions but prior to the display filters. All filters that use calculated fields that are the result of DD functions are in this category.

The process begins by reading any new or changed DDP in step **380**. Then a filter from the DD definition is read in step **381**. Next, in step **382**, an operand is tested, and the result is saved. Since all filter operations are on fields in the DD, each DD can be fully tested to see if it should be filtered out by reading only the DDP's calculated fields. For improved processing efficiency, the present invention executes all of a DDPs filters one after the other. The operation tests are simple Boolean tests to see if the field's value equals the value stored in the list (Dynamic Document) specified. The present invention stores the result (true or false) of each operation. The method then determines if this operand is the last operand to test in step **383**. If not, the process returns to step **382** to test the next operand. If all the operands have been tested, then the process continues to step **384**. In the step **384**, the method looks at the results of each operand to determine if the full filter results in a pass or fail. If the DDP passes the filter, the method proceeds to step **386** where the method appends to the DDP a flag for each filter indicating the filter includes that particular DDP. If the DDP fails the filter, the method jumps to step **388** to evaluate the filter type. In step **388**, further tests are performed to determine if the filter is a delete type. If the filter is a delete type, the DDP and its children DDPs are deleted in step **389**. Any DDP which has any parent DDP which are excluded is itself excluded. If the filter is not a delete type, then the flag is set to exclude for this filter in the current DDP's filter affects list in step **390**. Any DDP that is excluded by any active filter is not displayed in the currently open DDs. Next, step **391** determines whether there are additional filters to be processed. If so the method loops to **381**, otherwise the method tests whether this is the last MRPI to be processed in step **392**. If there are more MRPIs to process, the method returns to step **380**, otherwise, the process is complete.

Finally, it should be understood that the present invention also uses conventional sorting and display techniques. Sorting occurs dynamically when the DDPs are joined to the PRTs and displayed as pane rows. Sorting is done pane by pane in the same manner employed by conventional report write and query tools. The rows in a pane can be sorted by any of PRT and/or calculated fields in the pane. The user specifies the order in which each field sort is executed and whether to use an ascending or descending order. The user can also specify which, if any, sort levels should have total lines and what group by operand to use for each field for each level. The user can also have the present invention suppress displaying the row details and just display the totals. When the user selects (highlights) a total row in a pane, that pane's child panes display the rows for all the parent pane's detail rows that comprise the selected total row.

The display and reporting component of the present invention works similarly to many conventional query and reporting tools. By the time the present invention hands over the data to be displayed, it has already organized it, executed its calculations, filtered and sorted it. The present invention hands over one record (a DDP and its corresponding PRIs) to the screen forms display tool. All that remains is to place the record's values in the proper fields. Display rules entered by the user control the appearance of the panes, positioning the format of the PRT's fields, and what type of maintenance users can do to actual field values.

Users can open as many DDs at once as their hardware supports. Each DD can be autonomous or any DD can be linked to another. To link DD all the user need do is specify which on PRTs within the two DDs the link occurs. The two PRTs must be hooked together, or the PRT in both DD must be identical. At least one of the DDs must be linked at its top pane and a core linked DD must be designated as the controlled DD. Any DD can have only one controlling DD and circular controls are not permitted. When the user selects a new record instance in the controlling DD, the controlled DD is updated to display the record instance(s) that are hooked to the new controlling record instance. The present invention does this by executing the "find" function on the controlled DD; the find parameter is the foreign key or pointer of the controlling DD's current record type instance.

The present invention can save all the contents of memory it is currently using as a single file. If the user wishes to leave the terminal for a while, the user can save it and then recall it whenever required. This save is not shared with other users. Multiple copies of a session can be made and later modified just like as can be done with spreadsheets an word processors. In a multiple user environment, the changes to PRTs are stored in a relational database or XML documents and multiple users can access those changes. The definitions of MRTs, hooks, DDs, functions, filters, and sorts are also stored in the same database in special tables or XML documents setup by the present invention. Optionally MRPIs and DDPs can also be stored and maintained by the present invention in the same relational database or XML documents. It is useful to store these pointers in the repository because they do not need to then be regenerated for each user when he/she resumes working on the shared model.

While the present invention has been described with reference to certain preferred embodiments, those skilled in the art will recognize that various modifications may be provided.

For example, there may be other embodiments for the method of executing the functions, filters and sorts used in FIG. **4** in addition to those described above. Similarly, there may be other embodiments for the particular structure used for the MRTs, the pointer families, and DDs. These and other variations upon and modifications to the preferred embodiment are provided for by the present invention that is limited only by the following claims.

I claim:

1. A computer-implemented method of manipulating XML documents, comprising:
- organizing data components of the XML documents into data objects;
- identifying a plurality of primary record types for the XML documents;
- mapping the data components of each data object to one of the plurality of primary record types;
- organizing instances of the plurality of primary record types into a hierarchy to form a management record type;
- defining a dynamic document for display of an instance of the management record type through a user interface; and
- detecting modification of the data in the dynamic document via the user interface, and in response thereto modifying a data component in at least one of the XML documents.

2. A method as in claim **1**,
- wherein an instance of a one of the primary record types includes or points to a relational database table of that primary record type; and
- wherein the instance of the management record type points to instances of the primary record types.

3. A method as in claim **1**, wherein the management record type defines business objects and the instances of the management record type comprises the business objects.

4. A method as in claim **3**, wherein the business objects comprise invoices, bills of material, purchase orders, price books, forecasts, or fund transactions.

5. A method as in claim **1**, further comprising:
- organizing the instances of the primary record types into a second hierarchy to form a second management record type;
- creating a second dynamic document, the second dynamic document comprising a second user interface and an instance of the second management record type; and
- detecting modification of the data in the second dynamic document via the second user interface, and in response thereto modifying a data component in at least one of the XML documents.

6. A method as in claim **5**, wherein the instance of the management record type points to an instance of a first primary record type of the primary record types, and the instance of the second management record type points to the instance of the first primary record type.

7. A method as in claim **6**, wherein no two instances of the primary record types have identical values.

8. A method as in claim **1**, wherein the management record type defines multiple XML documents.

9. A method as in claim **1**, wherein the mapping comprises performing the following for each of the data objects:
- determining whether any of the plurality of primary record types corresponds to the data object;
- mapping the data components of the data object to a first primary record type of the plurality of primary record

types if the determining results in a determination that the first primary record type corresponds to the data object; and

creating a second primary record type corresponding to the data object and including the second primary record type in the plurality of primary record types if the determining results in a determination that none of the plurality of primary record types corresponds to the data object.

10. A program memory having instructions stored thereon, the instructions comprising:

instructions for organizing data components of one or more XML documents into data objects;

instructions for identifying a plurality of primary record types for the XML documents;

instructions for mapping the data components of each data object to one of the plurality of primary record types;

instructions for organizing instances of the plurality of primary record types into a hierarchy to form a management record type;

instructions for defining a dynamic document for display of an instance of the management record type through a user interface; and

instructions for detecting modification of the data in the dynamic document via the user interface, and in response thereto modifying a data component in at least one of the XML documents.

11. The program memory of claim **10**,

wherein an instance of a one of the primary record types includes or points to a relational database table of that primary record type; and

wherein the instance of the management record type points to instances of the primary record types.

12. The program memory of claim **10**, wherein the management record type defines business objects and the instances of the management record type comprises the business objects.

13. The program memory of claim **12**, wherein the business objects comprise invoices, bills of material, purchase orders, price books, forecasts, or fund transactions.

14. The program memory of claim **10**, the instructions further comprising:

instructions for organizing the instances of the primary record types into a second hierarchy to form a second management record type;

instructions for creating a second dynamic document, the second dynamic document comprising a second user interface and an instance of the second management record type; and

instructions for detecting modification of the data in the second dynamic document via the second user interface, and in response thereto modifying a data component in at least one of the XML documents.

15. The program memory of claim **14**, wherein the instance of the management record type and the instance of the second management record type point to one or more same instances of the primary record types.

16. The program memory of claim **15**, wherein no two instances of the primary record types have identical values.

17. The program memory of claim **10**, wherein the management record type defines multiple XML documents.

18. The program memory of claim **10**, wherein the instructions for mapping comprise instructions for performing the following for each of the data objects:

determining whether any of the plurality of primary record types corresponds to the data object;

mapping the data components of the data object to a first primary record type of the plurality of primary record

types if the determining results in a determination that the first primary record type corresponds to the data object; and

creating a second primary record type corresponding to the data object and including the second primary record type in the plurality of primary record types if the determining results in a determination that none of the plurality of primary record types corresponds to the data object.

19. An apparatus for manipulating XML documents, comprising:

means for organizing data components of one or more XML documents into data objects;

means for organizing the relational data into object model data;

means for identifying a plurality of primary record types for the XML documents;

means for mapping the data components of each data object to one of the plurality of primary record types;

means for organizing instances of the plurality of primary record types into a hierarchy to form a management record type;

means for defining a dynamic document for display of an instance of the management record type through a user interface;

means for detecting modification of the data in the dynamic document via the user interface, and in response thereto modifying a data component in an XML document.

20. The apparatus of claim **19**, wherein the means for mapping comprises means for performing the following for each of the data objects:

determining whether any of the plurality of primary record types corresponds to the data object;

mapping the data components of the data object to a first primary record type of the plurality of primary record types if the determining results in a determination that the first primary record type corresponds to the data object; and

creating a second primary record type corresponding to the data object and including the second primary record type in the plurality of primary record types if the determining results in a determination that none of the plurality of primary record types corresponds to the data object.

21. An apparatus for manipulating XML documents, comprising:

a processor;

a component that organizes data components of one or more XML documents into data objects;

a component that identifies a plurality of primary record types for the XML documents;

a component that maps the data components of each data object to one of the plurality of primary record types;

a component that organizes the instances of the plurality of primary record types into a hierarchy to form a management record type;

a component that defines a dynamic document for display of an instance of a management record type through a user interface; and

a component that detects modification of the data in the dynamic document via the user interface, and in response thereto modifies a data component in an XML document.

22. The apparatus of claim **21**,

wherein an instance of one of the primary record types includes or points to a relational database table of that primary record type; and

wherein the instance of the management record type points to instances of the primary record types.

23. The apparatus of claim **21**, wherein the management record type defines business objects and the instances of the management record type comprises the business objects.

24. The apparatus of claim **23**, wherein the business objects comprise invoices, bills of material, purchase orders, price books, forecasts, or fund transactions.

25. The apparatus of claim **21**, further comprising:

a component that organizes the instances of the primary record types into a second hierarchy to form a second management record type;

a component that creates a second dynamic document, the second dynamic document comprising a second user interface and an instance of the second management record type; and

a component that detects modification of the data in the second dynamic document via the second user interface, and in response thereto modifying a data component in at least one of the XML documents.

26. The apparatus of claim **25**, wherein the instance of the management record type and the instance of the second management record type point to one or more same instances of the primary record types.

27. The apparatus of claim **26**, wherein no two instances of the primary record types have identical values.

28. The apparatus of claim **21**, wherein the management record type defines multiple XML documents.

29. The apparatus of claim **21**, wherein the component that maps the data components is configured to perform the following for each of the data objects:

determining whether any of the plurality of primary record types corresponds to the data object;

mapping the data components of the data object to a first primary record type of the plurality of primary record types if the determining results in a determination that the first primary record type corresponds to the data object; and

creating a second primary record type corresponding to the data object and including the second primary record type in the plurality of primary record types if the determining results in a determination that none of the plurality of primary record types corresponds to the data object.

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UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO.	: 7,984,081 B1	Page 1 of 1
APPLICATION NO.	: 11/523746	
DATED	: July 19, 2011	
INVENTOR(S)	: VanderDrift	

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 18, line 31, in Claim 2, delete “a one” and insert -- one --.

Column 19, line 28, in Claim 11, delete “a one” and insert -- one --.

Column 20, line 52, in Claim 21, delete “the instances” and insert -- instances --.

Signed and Sealed this
Twenty-second Day of November, 2011

David J. Kappos

David J. Kappos
Director of the United States Patent and Trademark Office