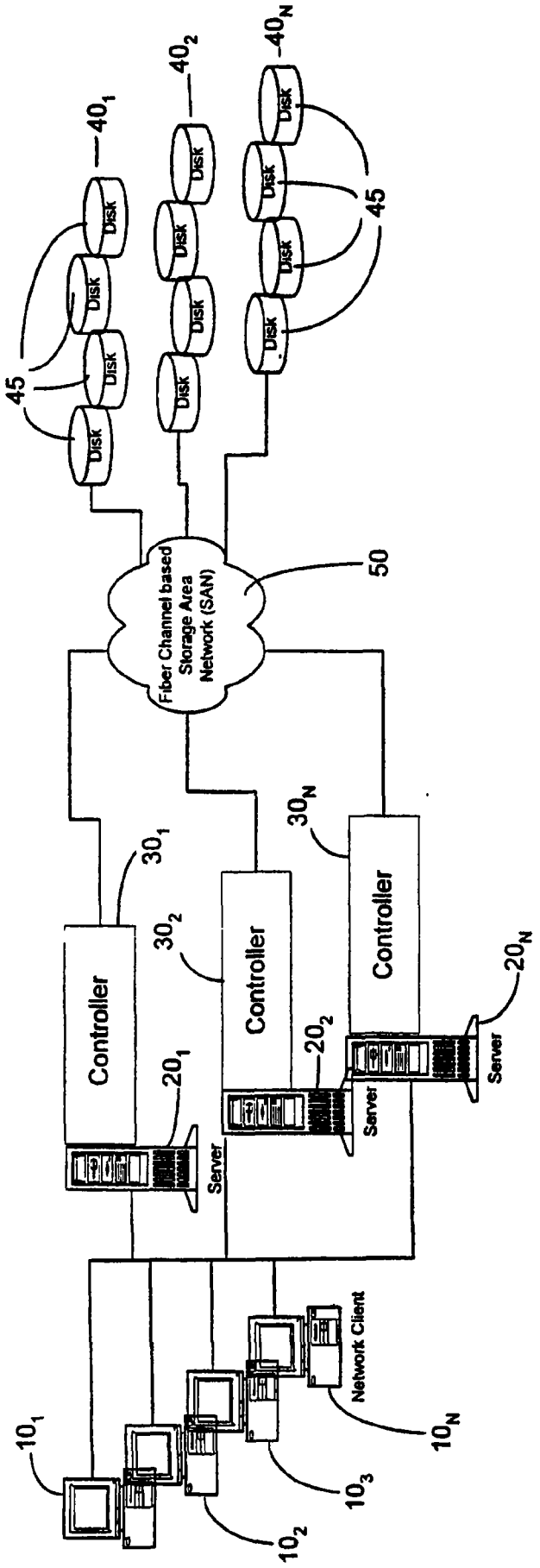


Figure 1

G00001

163163

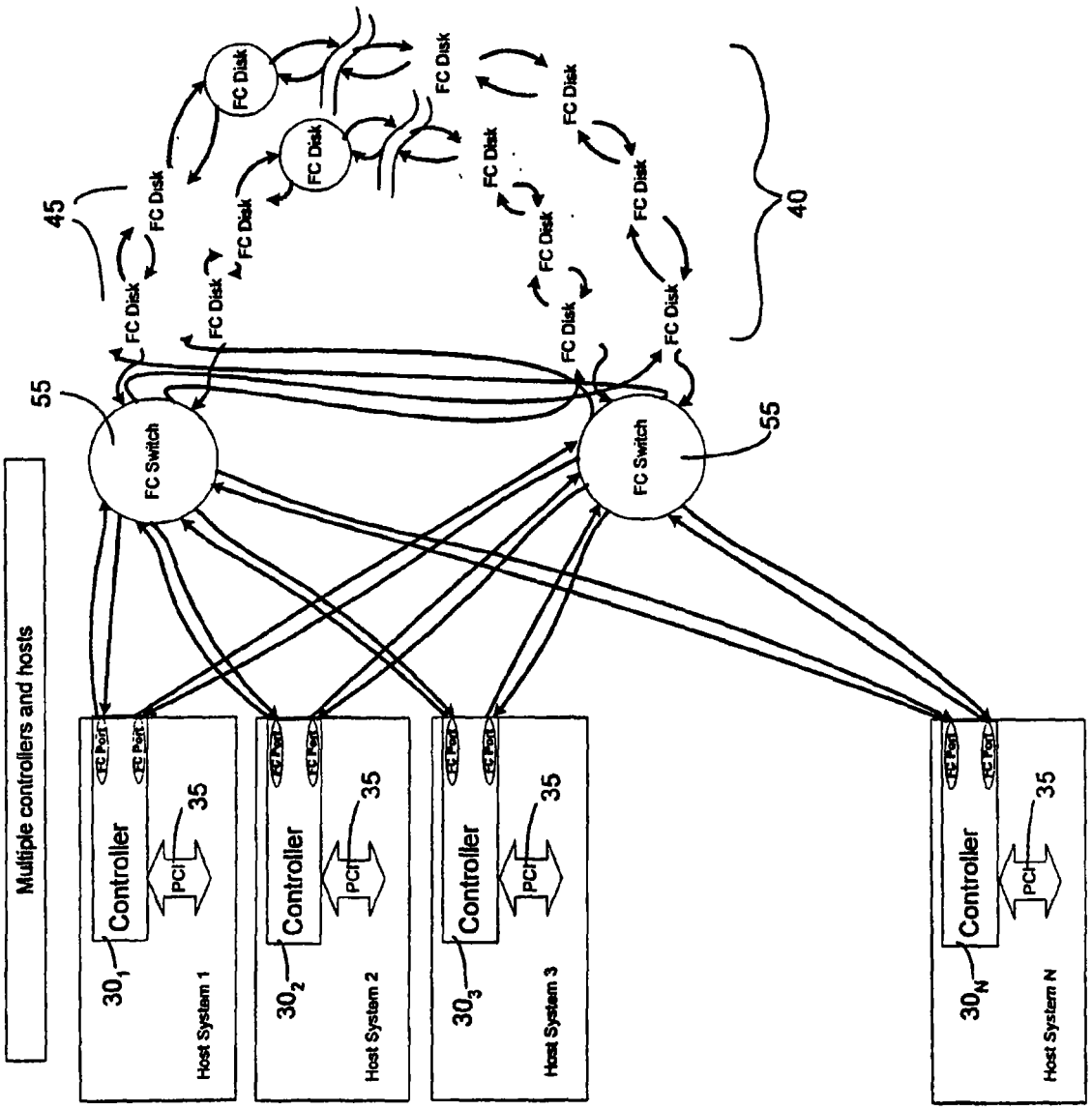

Multiple controllers and hosts
FC Switch
FC Switch
55
55
45
40
FC Disk
Controller
PCI
35
30_1
30_2
30_3
30_N
Host System 1
Host System 2
Host System 3
Host System N

Figure 2

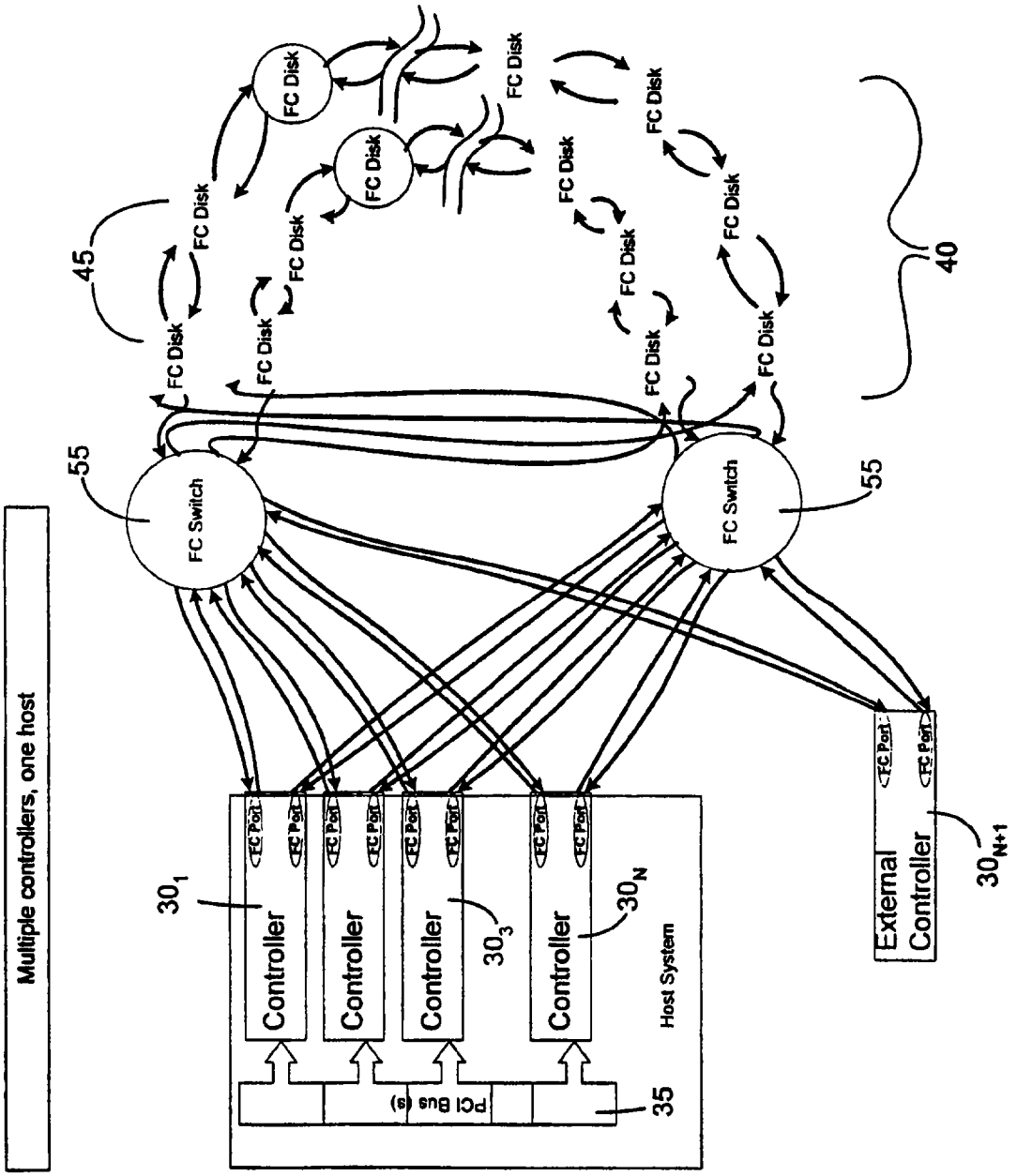

Multiple controllers, one host
FC Switch
FC Switch
55
55
45
40
FC Disk
Controller
Controller
Controller
Controller
External Controller
FC Port
PCI Bus (s)
Host System
35
30_1
30_3
30_N
30_{N+1}

Figure 3

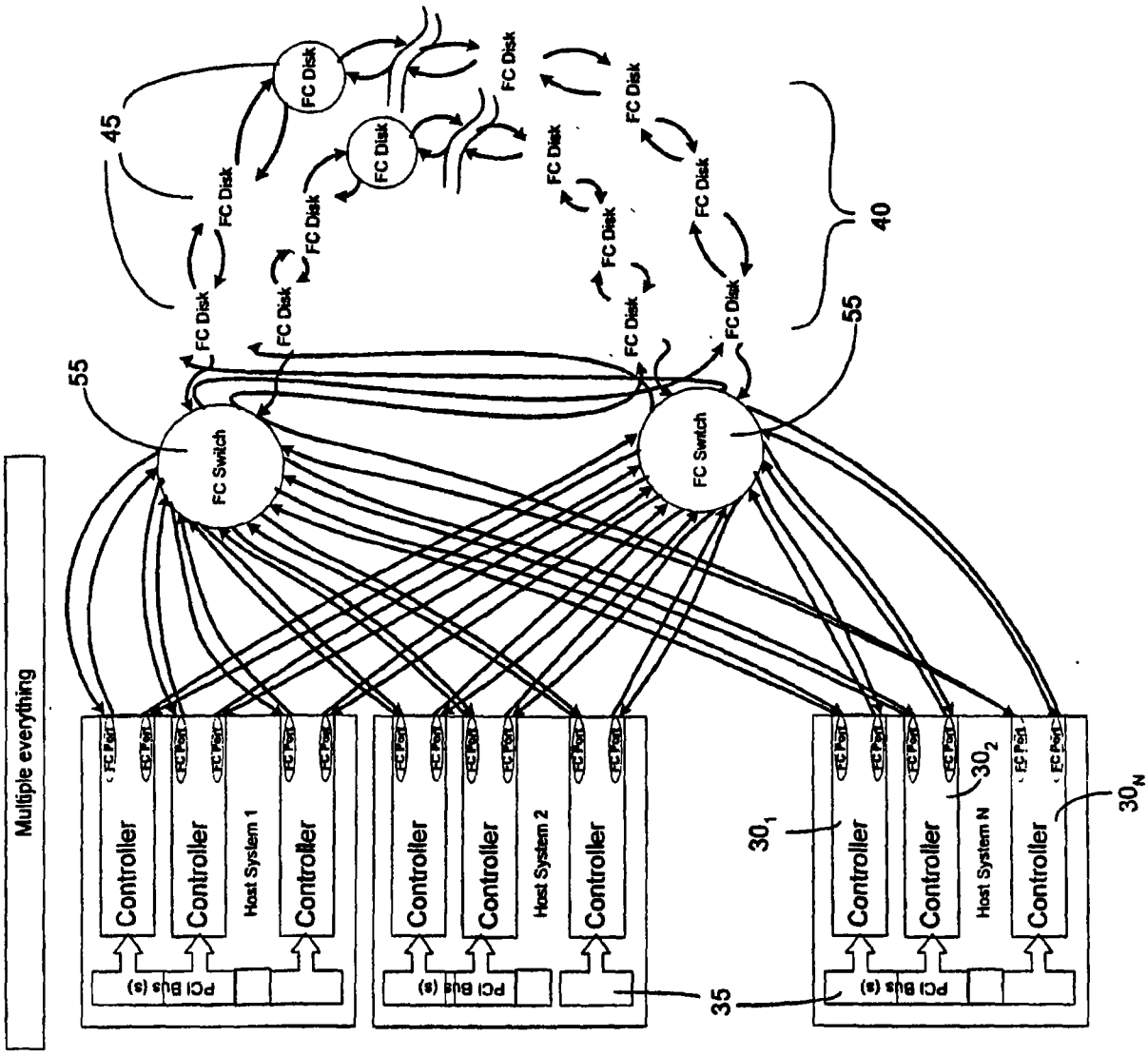

Multiple everything
FC Switch
FC Switch
FC Disk
45
40
55
55
Controller
Host System 1
Host System 2
Host System N
PCI Bus (s)
35
30_1
30_2
30_N

Figure 4

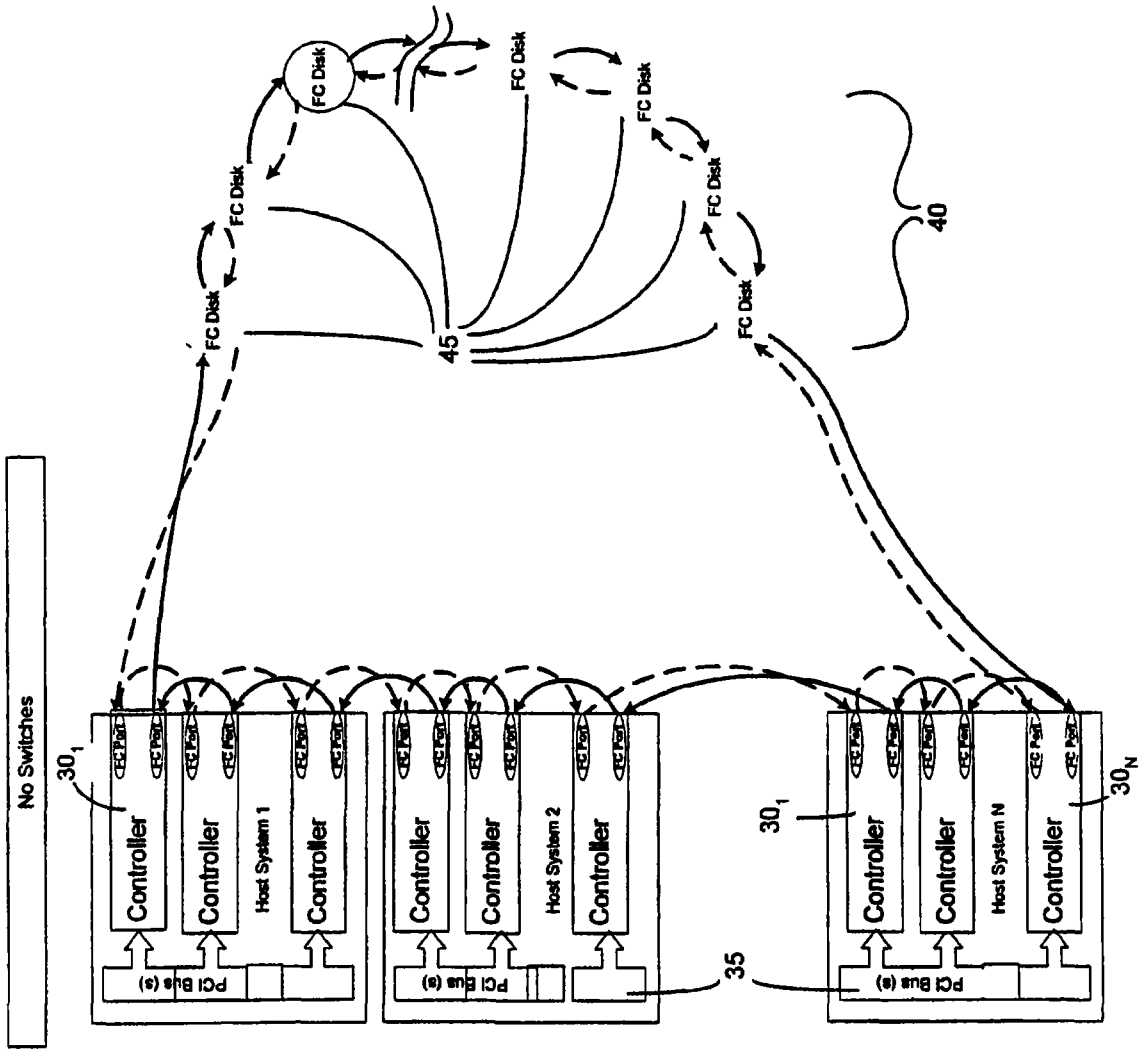

FC Disk
FC Disk
FC Disk
FC Disk
FC Disk
FC Disk
40
45
No Switches
30_1
Controller
Controller
Host System 1
Controller
Controller
Controller
Host System 2
Controller
30_1
Controller
Controller
Host System N
Controller
30_N
PCI Bus (s)
PCI Bus (s)
35
PCI Bus (s)

Figure 5

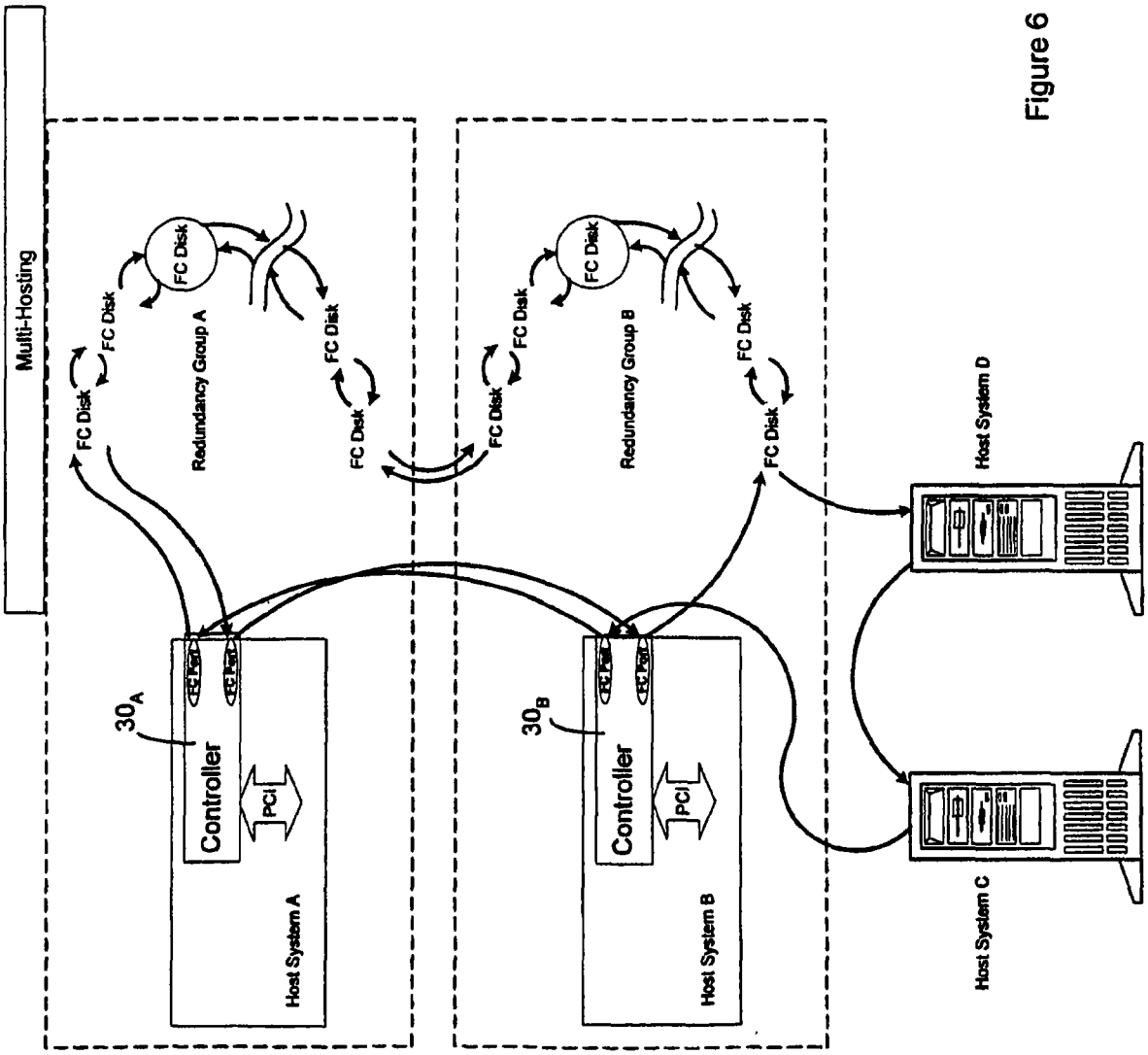

Multi-Hosting
FC Disk
Redundancy Group A
Redundancy Group B
30A
30B
Controller
PCI
Host System A
Host System B
Host System C
Host System D

Figure 6

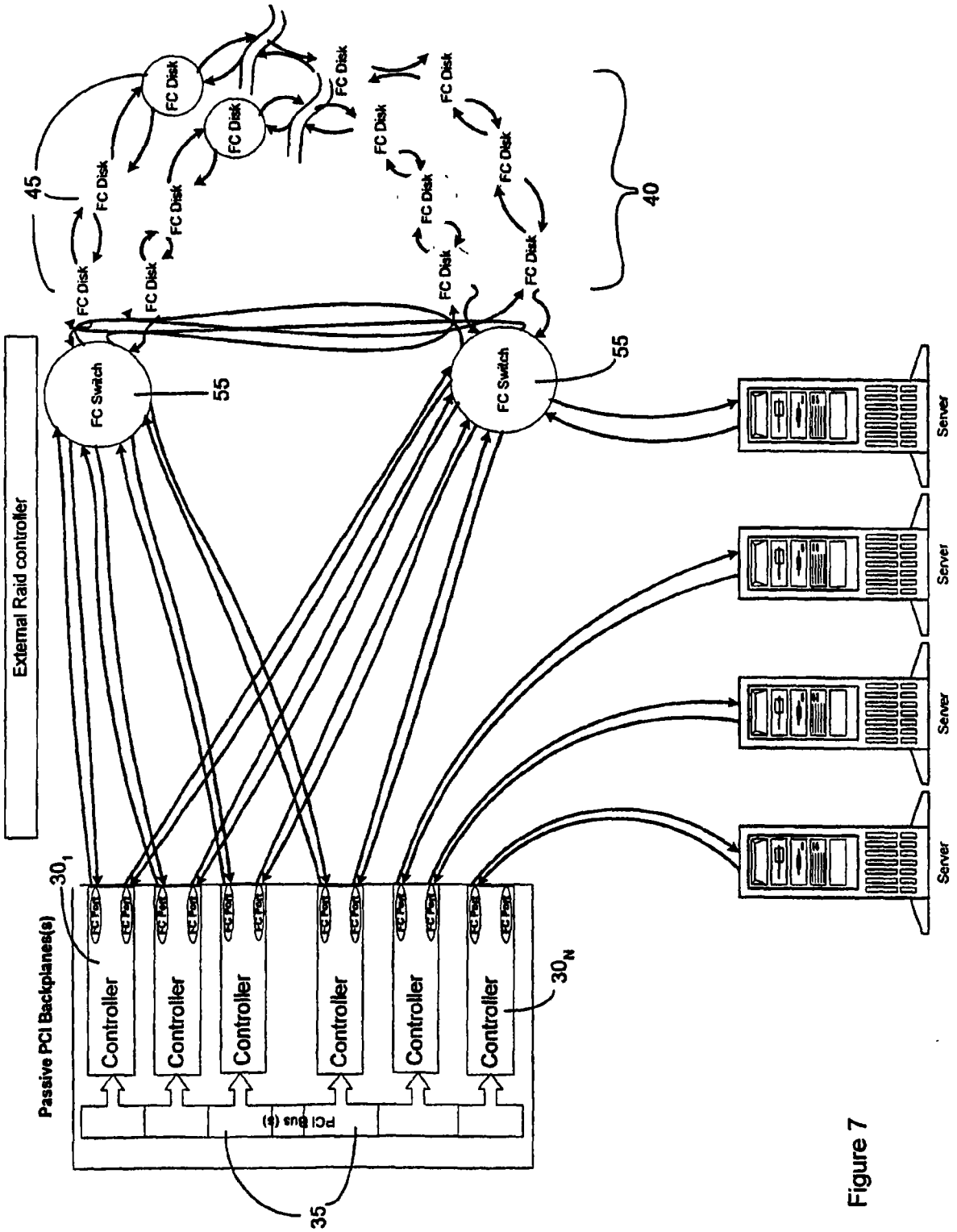

External Raid controller
Passive PCI Backplanes(s)
30_1
30_N
Controller
PCI Bus (s)
35
FC Switch
55
FC Disk
45
40
Server

Figure 7

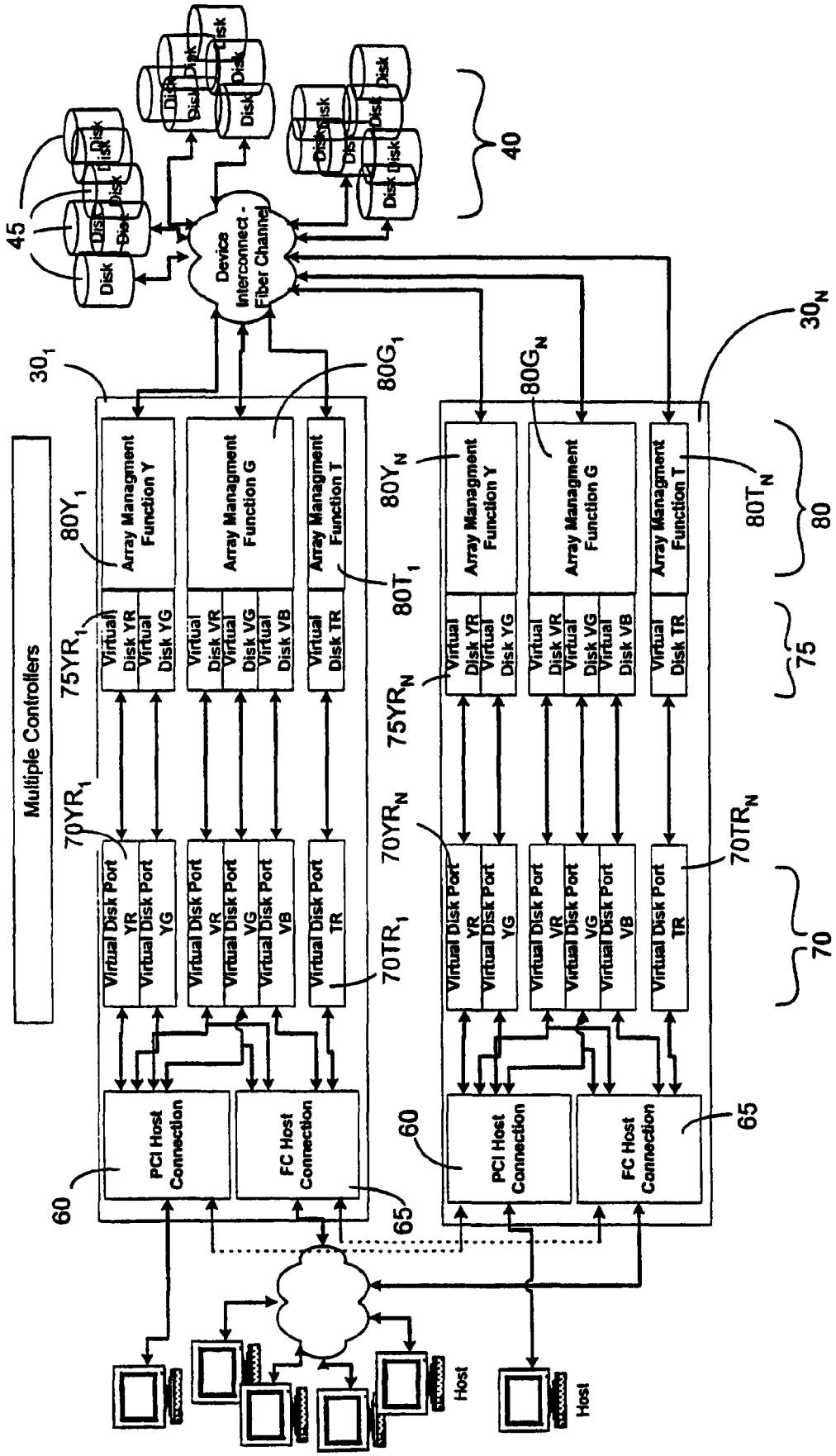

Multiple Controllers
Device Interconnect - Fiber Channel
Disk
40
45
30$_1$
30$_N$
80G$_1$
80G$_N$
80Y$_1$
80Y$_N$
80T$_1$
80T$_N$
80
Array Managment Function Y
Array Managment Function G
Array Managment Function T
75YR$_1$
75YR$_N$
75
Virtual Disk YR
Virtual Disk YG
Virtual Disk VR
Virtual Disk VG
Virtual Disk VB
Virtual Disk TR
70YR$_1$
70YR$_N$
70TR$_1$
70TR$_N$
70
Virtual Disk Port YR
Virtual Disk Port YG
Virtual Disk Port VR
Virtual Disk Port VG
Virtual Disk Port VB
Virtual Disk Port TR
60
65
PCI Host Connection
FC Host Connection
Host

Figure 8

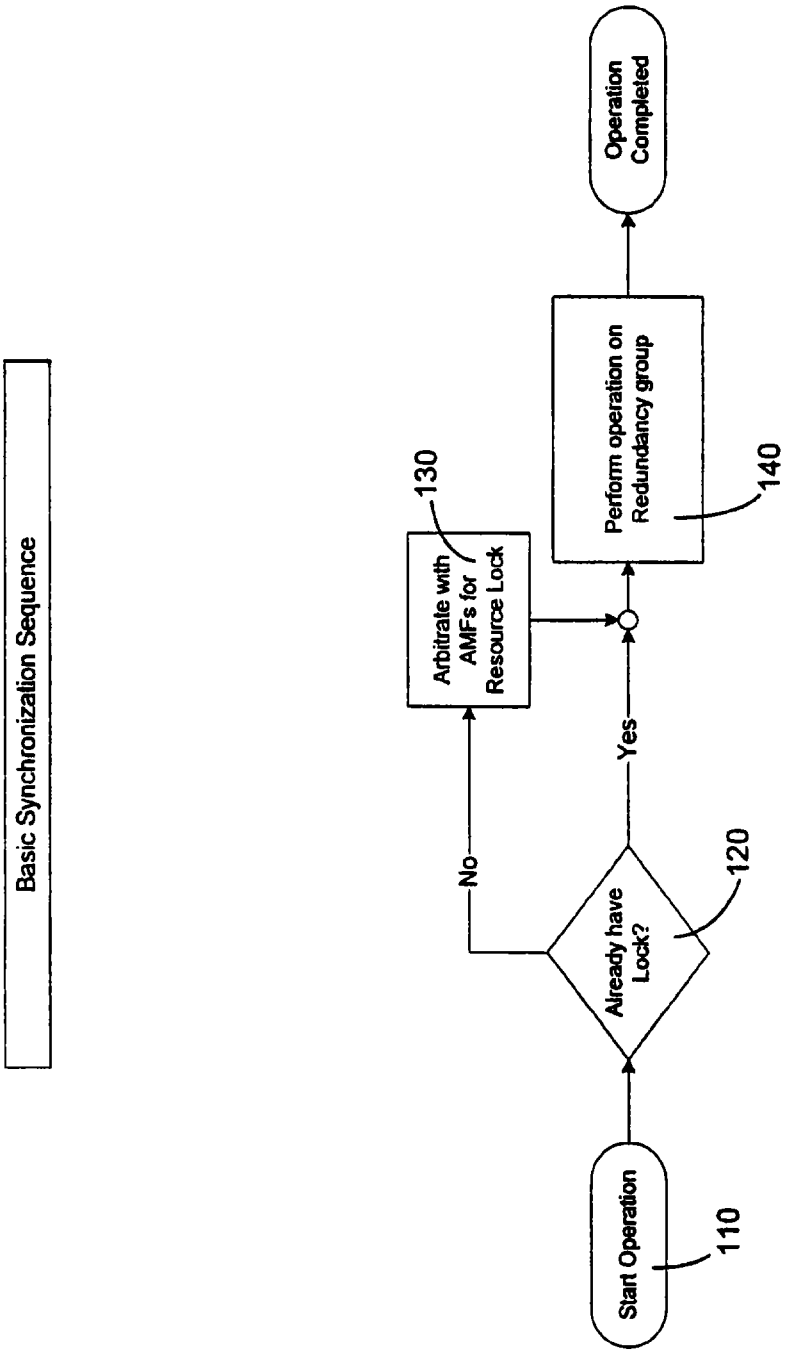

Basic Synchronization Sequence
Start Operation
110
Already have Lock?
120
No
Yes
Arbitrate with AMFs for Resource Lock
130
Perform operation on Redundancy group
140
Operation Completed

Figure 9

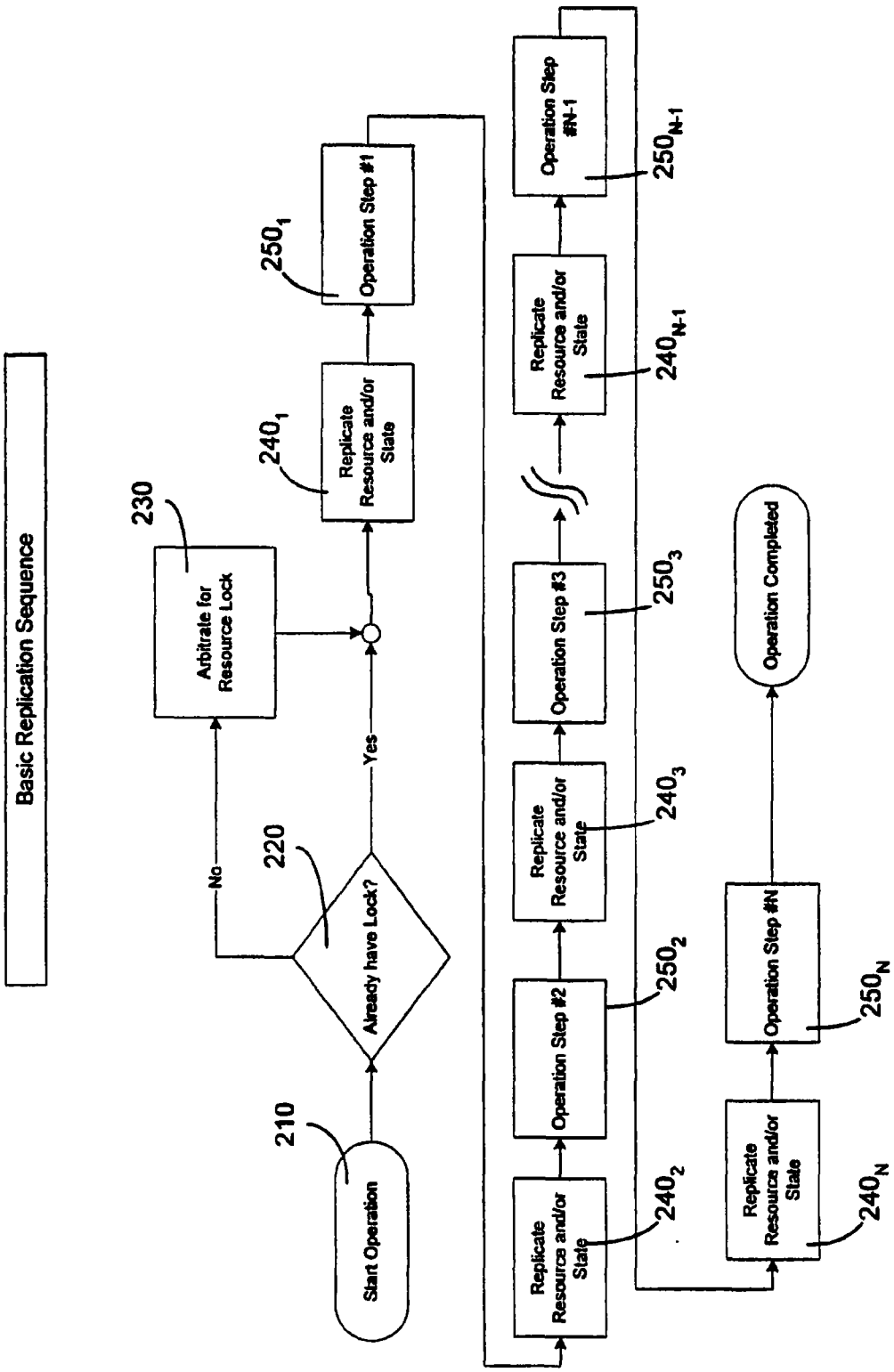

Basic Replication Sequence
Start Operation
210
Already have Lock?
220
No
Yes
Arbitrate for Resource Lock
230
Replicate Resource and/or State
240$_1$
Operation Step #1
250$_1$
Replicate Resource and/or State
240$_2$
Operation Step #2
250$_2$
Replicate Resource and/or State
240$_3$
Operation Step #3
250$_3$
Replicate Resource and/or State
240$_{N-1}$
Operation Step #N-1
250$_{N-1}$
Replicate Resource and/or State
240$_N$
Operation Step #N
250$_N$
Operation Completed

Figure 10

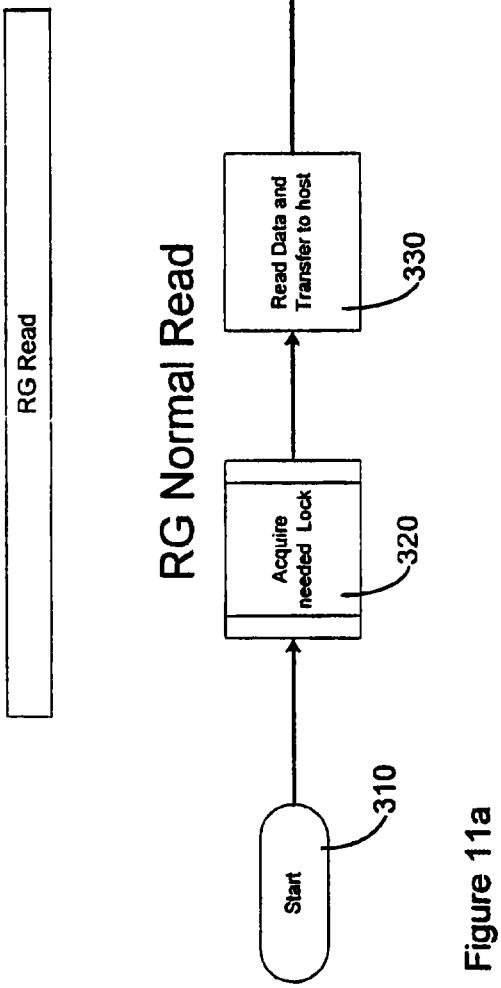


Figure 11a

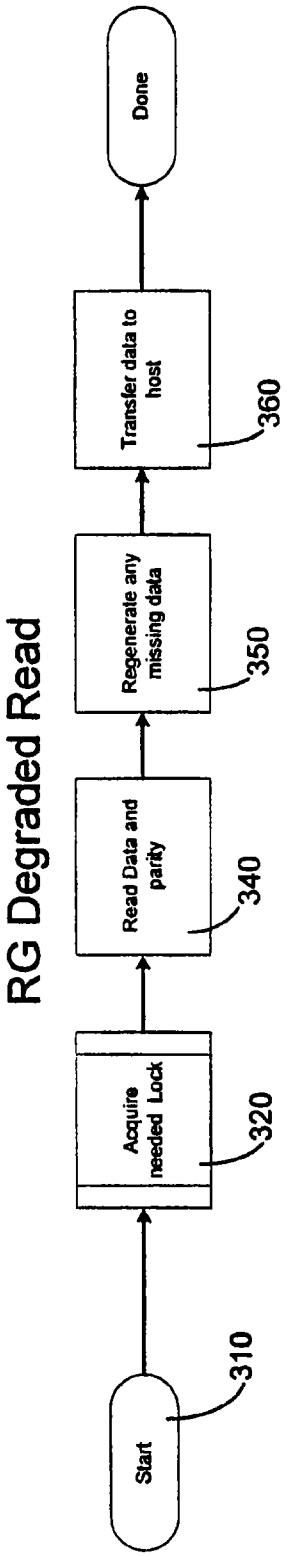


Figure 11b

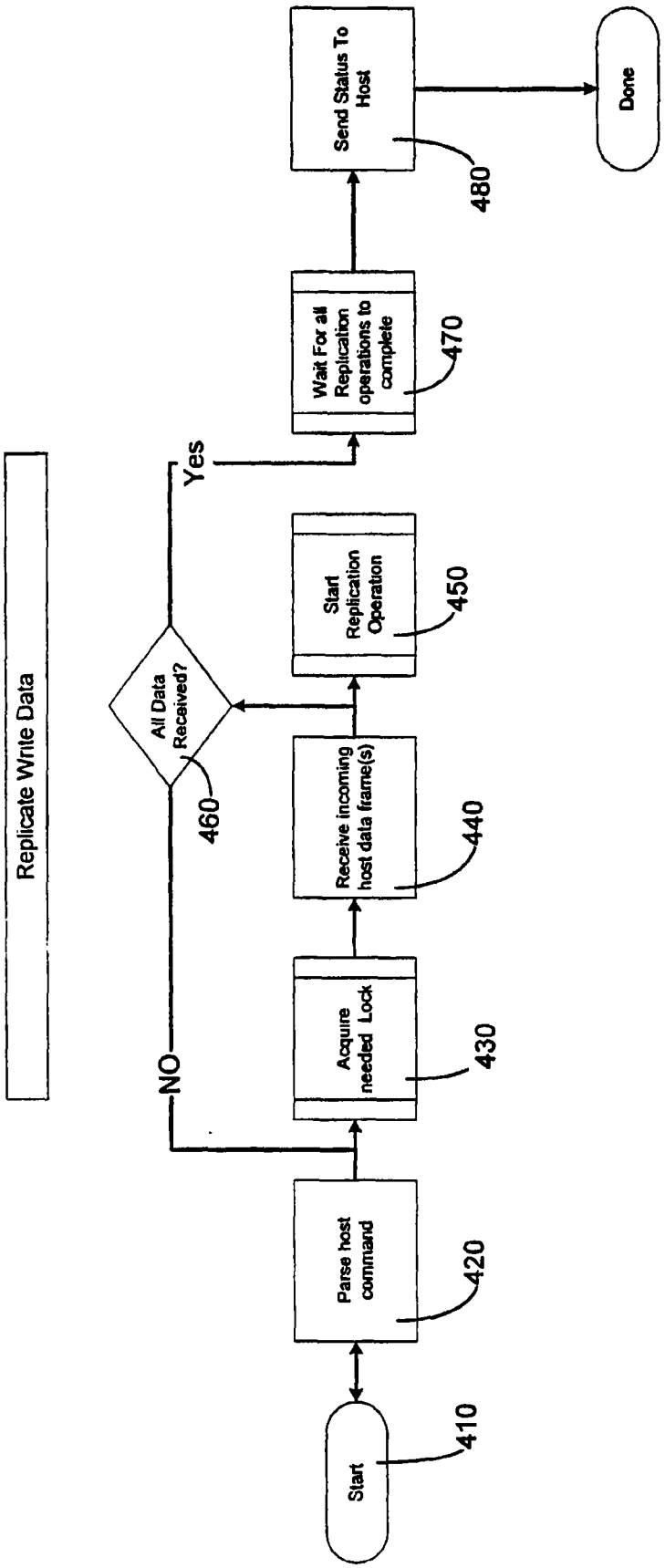

Replicate Write Data
Start
410
Parse host command
420
Acquire needed Lock
430
Receive incoming host data frame(s)
440
All Data Received?
460
NO
Yes
Start Replication Operation
450
Wait For all Replication operations to complete
470
Send Status To Host
480
Done

Figure 12

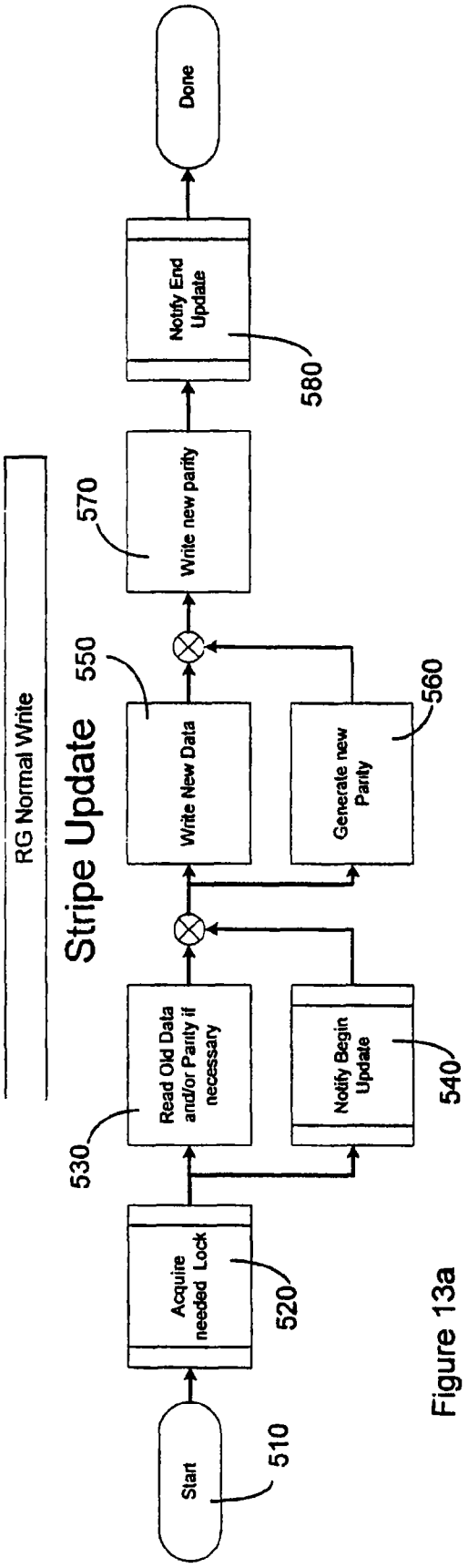


Figure 13a

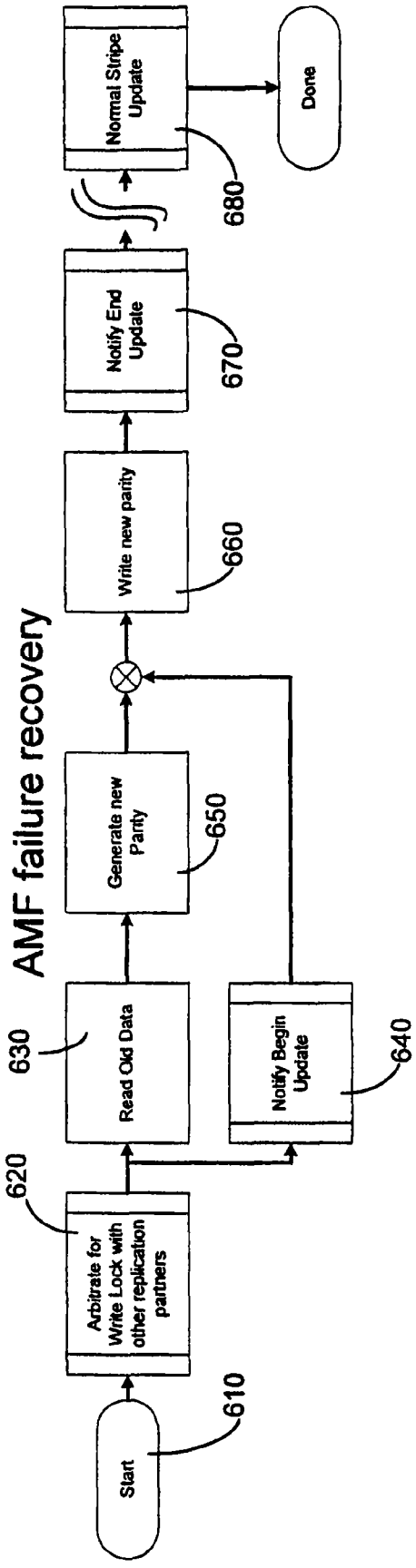


Figure 13b

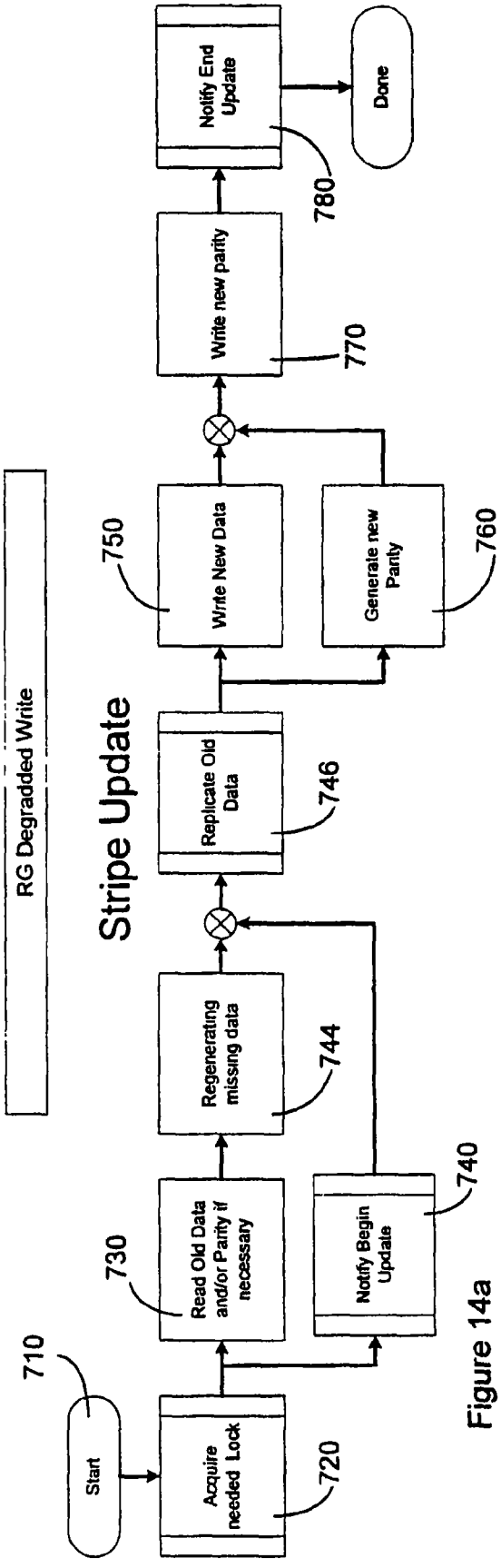


Figure 14a

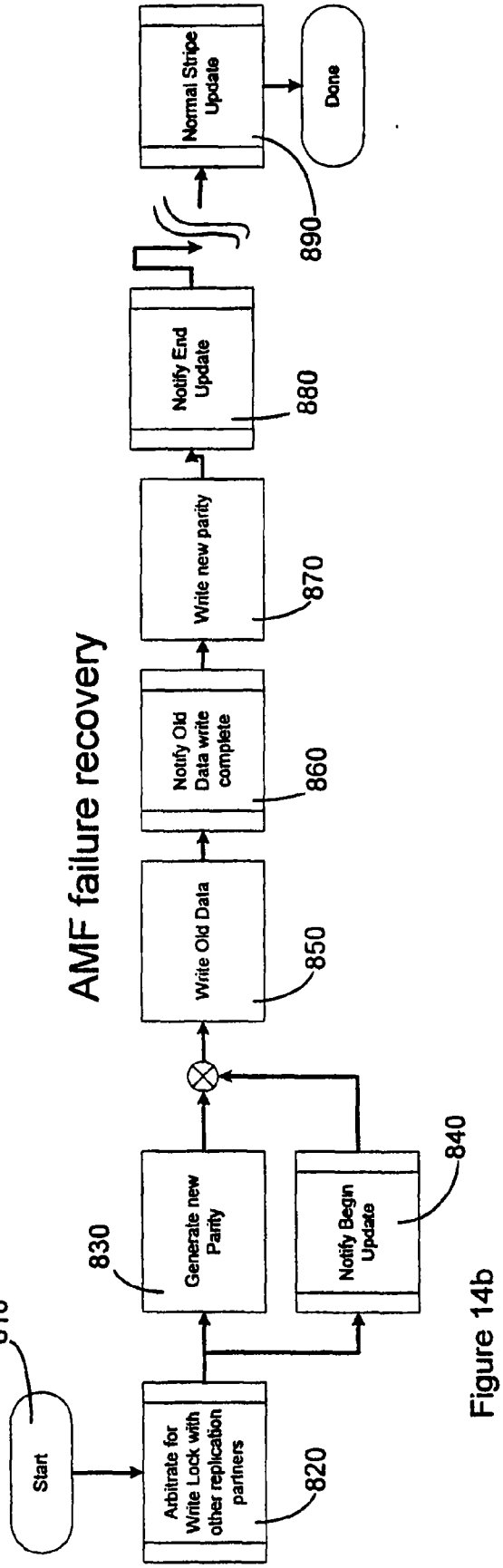


Figure 14b

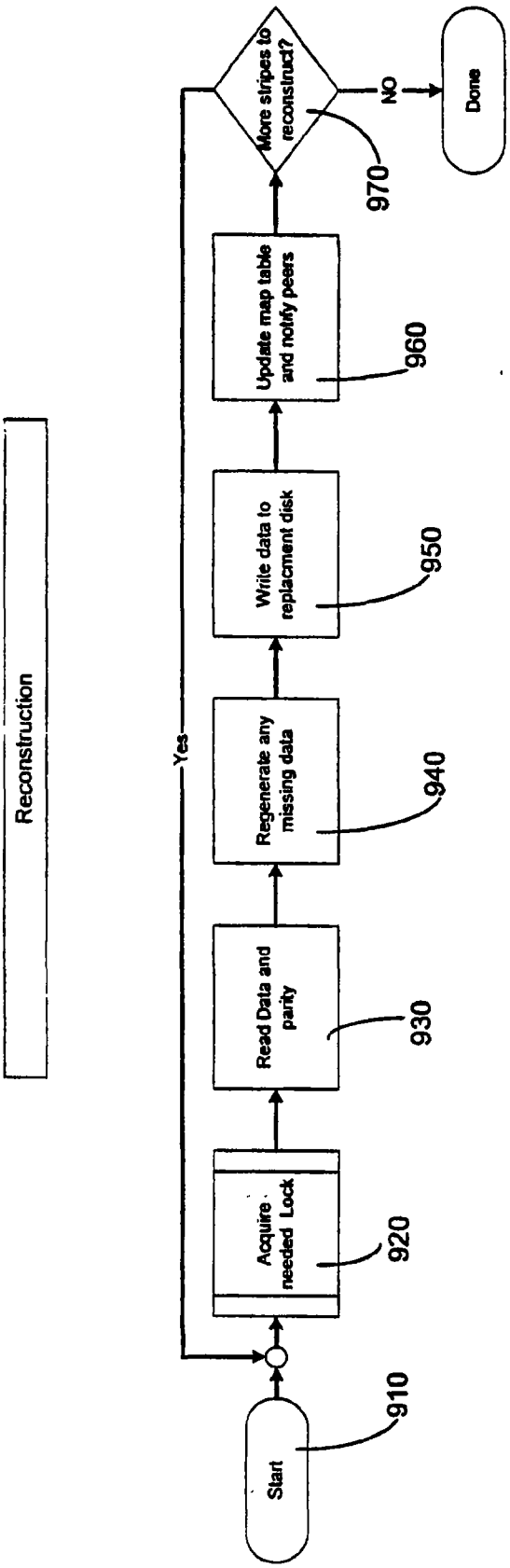

Reconstruction
Start
910
Acquire needed Lock
920
Read Data and parity
930
Regenerate any missing data
940
Write data to replacment disk
950
Update map table and notify peers
960
More stripes to reconstruct?
970
Yes
NO
Done

Figure 15

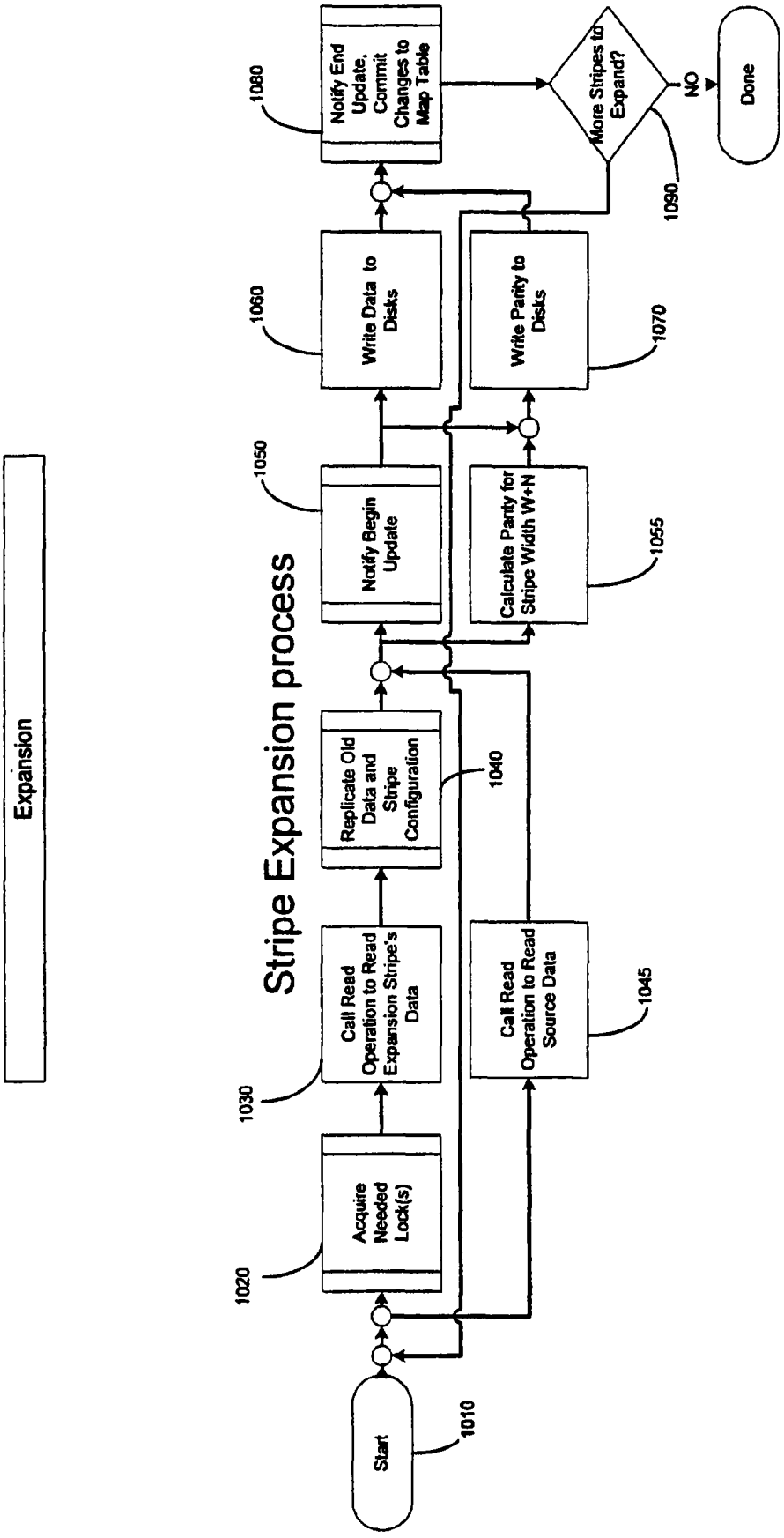

Expansion
Stripe Expansion process
Start
1010
Acquire Needed Lock(s)
1020
Call Read Operation to Read Expansion Stripe's Data
1030
Replicate Old Data and Stripe Configuration
1040
Call Read Operation to Read Source Data
1045
Notify Begin Update
1050
Calculate Party for Stripe Width W+N
1055
Write Data to Disks
1060
Write Parity to Disks
1070
Notify End Update, Commit Changes to Map Table
1080
More Stripes to Expand?
1090
NO
Done

Figure 16

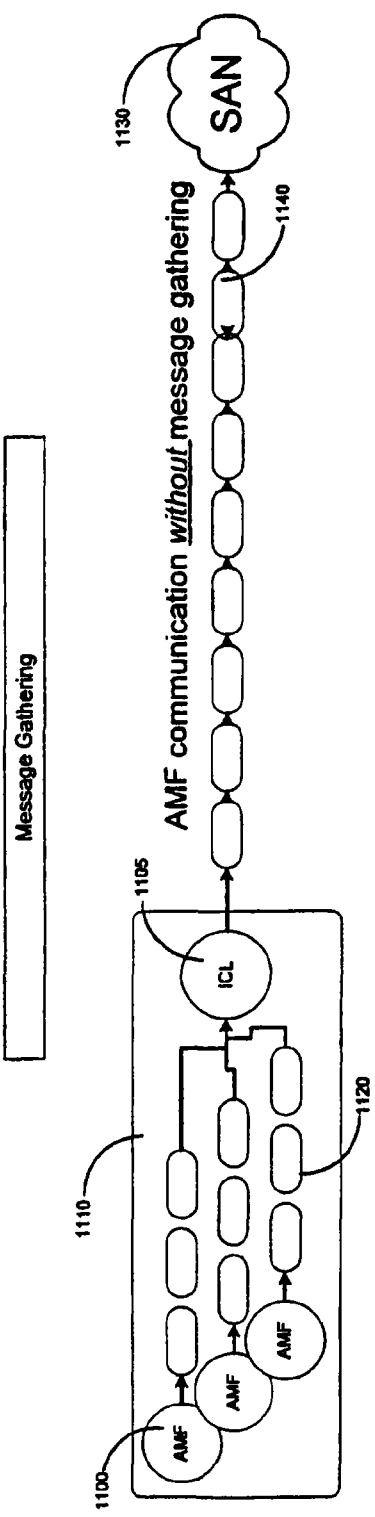


Figure 17a

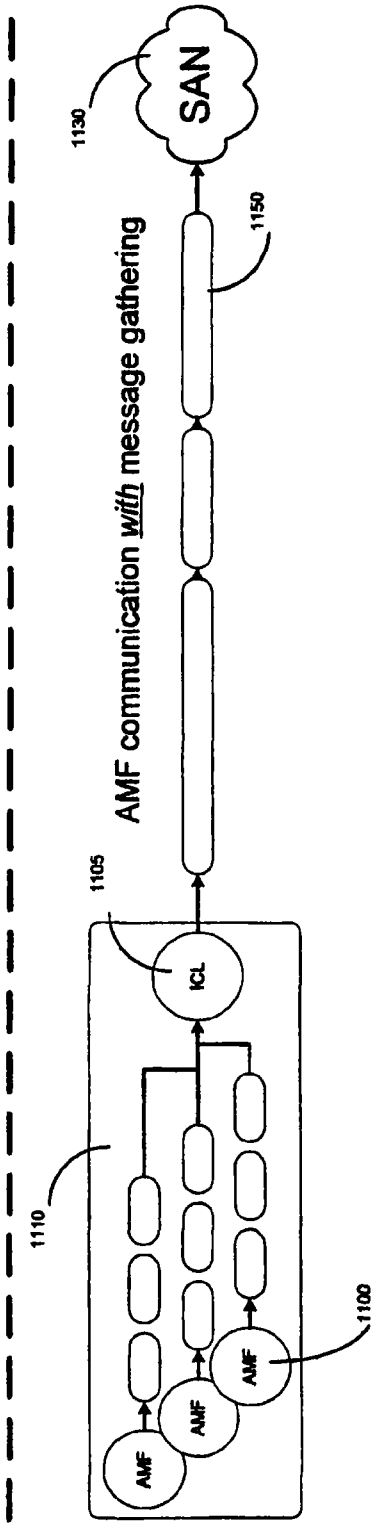


Figure 17b

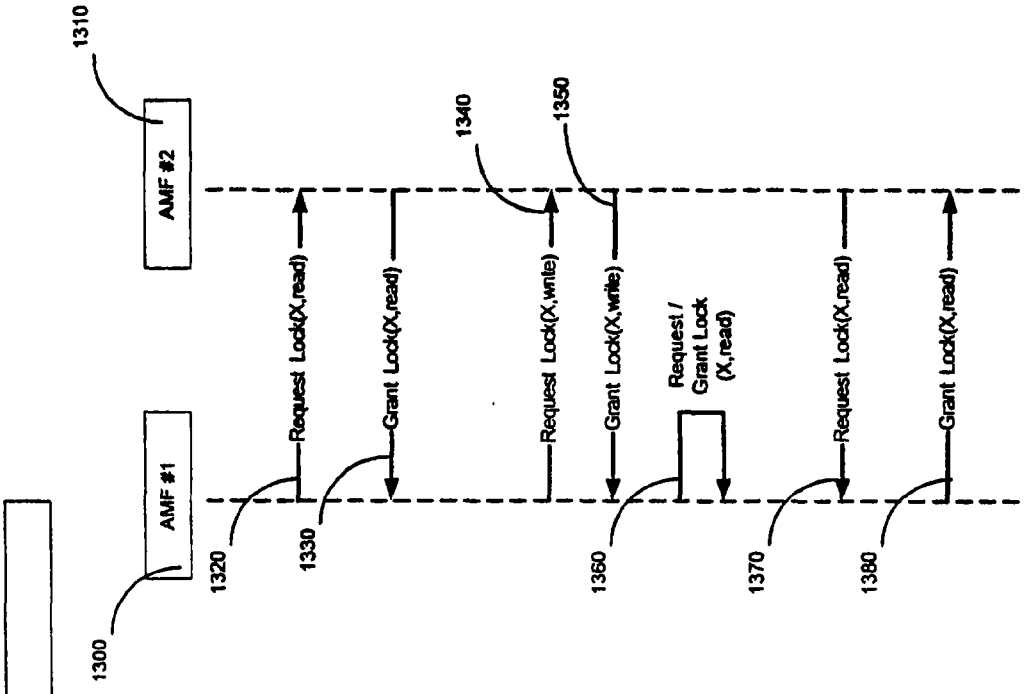


Figure 19

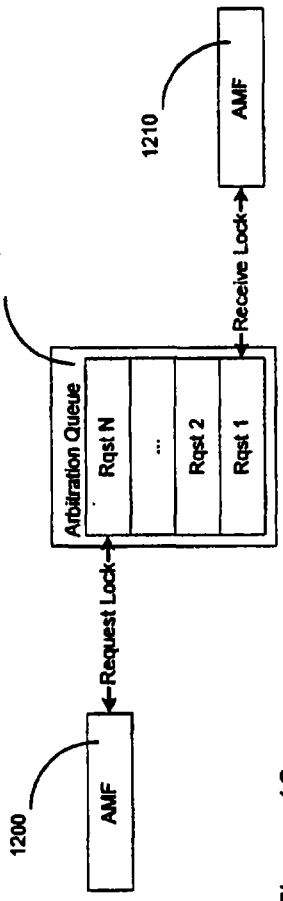


Figure 18a

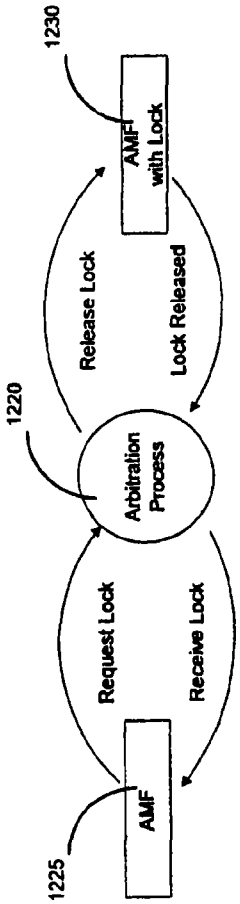


Figure 18b

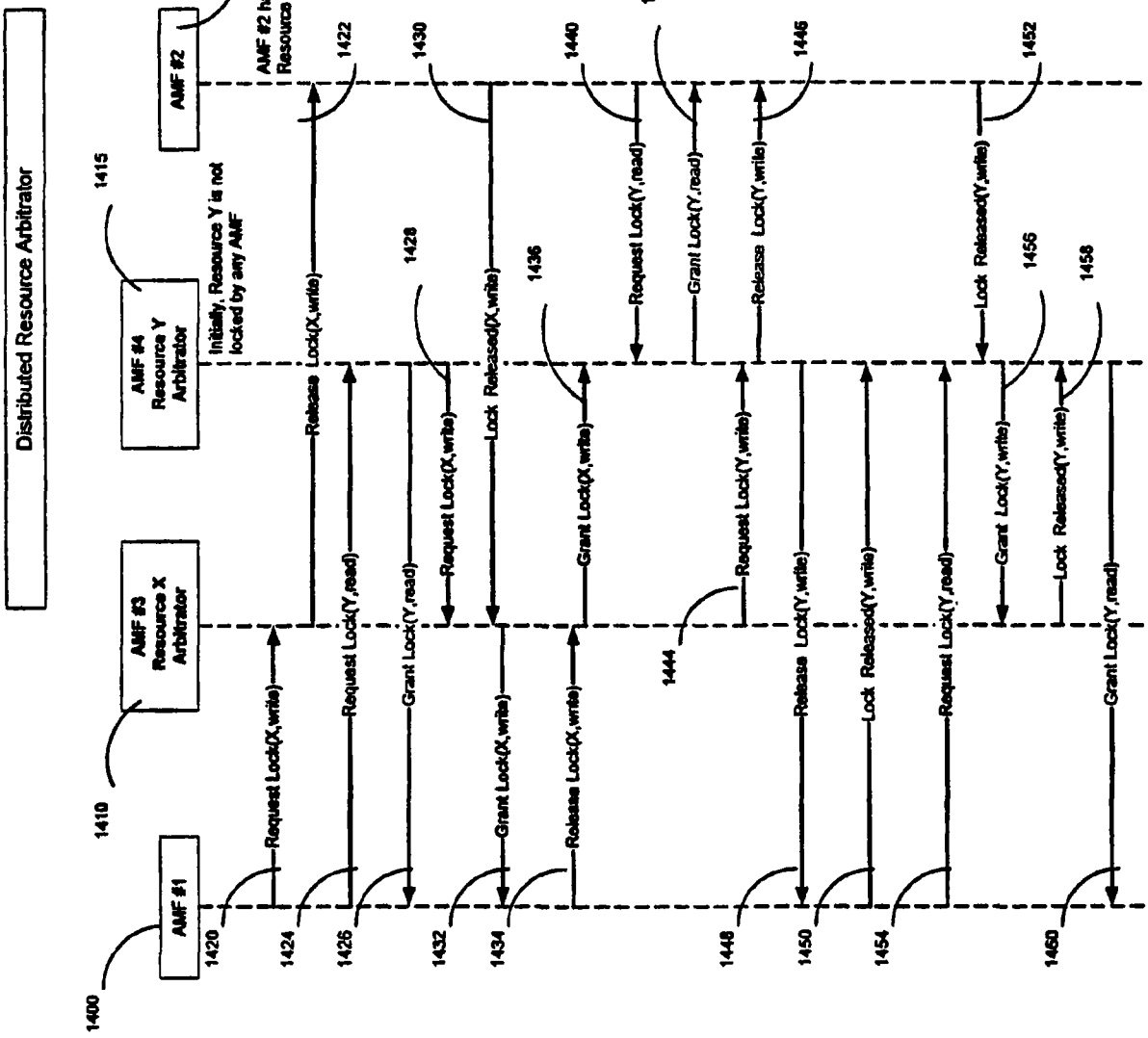

Distributed Resource Arbitrator
AMF #1
AMF #3 Resource X Arbitrator
AMF #4 Resource Y Arbitrator
AMF #2
1400
1410
1415
1405
AMF #2 has lock initially for Resource X.
Initially, Resource Y is not locked by any AMF
Request Lock(X,write)
Release Lock(X,write)
Request Lock(Y,read)
Grant Lock(Y,read)
Request Lock(X,write)
Lock Released(X,write)
Grant Lock(X,write)
Release Lock(X,write)
Request Lock(Y,read)
Grant Lock(Y,read)
Release Lock(Y,write)
Request Lock(Y,write)
Release Lock(Y,write)
Lock Released(Y,write)
Request Lock(Y,read)
Grant Lock(Y,write)
Lock Released(Y,write)
Grant Lock(Y,read)
1420
1422
1424
1426
1428
1430
1432
1434
1436
1440
1442
1444
1446
1448
1450
1452
1454
1456
1458
1460

Figure 20