US 20190028414A1

(19) United States

(12) Patent Application Publication (10) Pub. No.: US 2019/0028414 A1

Walker et al. (43) Pub. Date: Jan. 24, 2019

(54) SYSTEM AND METHOD FOR PROVIDING A COMMUNICATIONS LAYER TO ENABLE FULL PARTICIPATION IN A DISTRIBUTED COMPUTING ENVIRONMENT THAT USES MULTIPLE MESSAGE TYPES

(71) Applicant: **n.io Innovation, LLC**, Broomfield, CO (US)

(72) Inventors: **James David Walker**, Denver, CO (US); **Matthew R. Dodge**, Dana Point, CA (US); **James A. Holmes**, Broomfield, CO (US); **Franky Martin**, Boca Raton, FL (US)

(21) Appl. No.: **16/038,786**

(22) Filed: **Jul. 18, 2018**

Related U.S. Application Data

(60) Provisional application No. 62/534,503, filed on Jul. 19, 2017, provisional application No. 62/599,981, filed on Dec. 18, 2017.

Publication Classification

(51) **Int. Cl.**

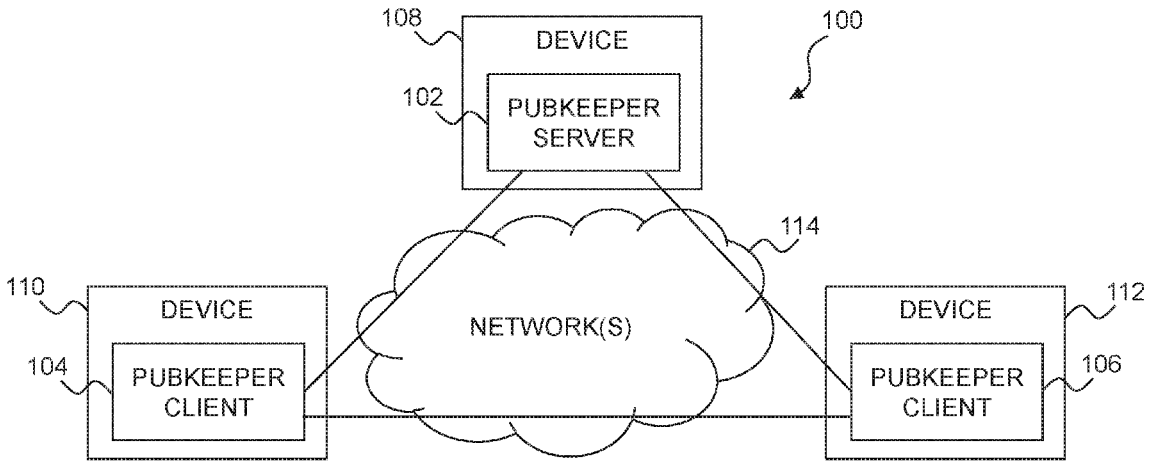
H04L 12/58	(2006.01)
H04L 29/08	(2006.01)
H04L 29/06	(2006.01)

(52) **U.S. Cl.**

CPC ***H04L 51/066*** (2013.01); ***H04L 51/38*** (2013.01); ***H04L 63/0428*** (2013.01); ***H04L 67/104*** (2013.01); ***H04L 67/26*** (2013.01); ***H04L 67/2823*** (2013.01)

(57) **ABSTRACT**

An improved system and method for communication among clients using multiple messaging types are disclosed. In one example, a client includes at least one brew that interfaces with a module. The module encapsulates a transfer mechanism for sending and receiving messages using a particular message type. The client further includes at least one brewer or patron, but may include many brewers and/or patrons, each of which corresponds to at least one topic. An application using the client can send messages to other clients using a standardized interface provided by all brewers and may receive messages from other clients either from patrons using a standardized interface provided by all patrons or from the brew.



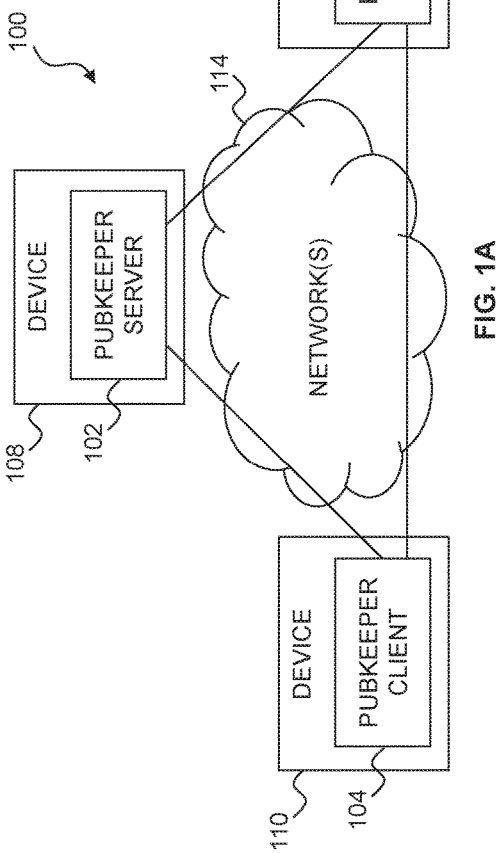


FIG. 1A

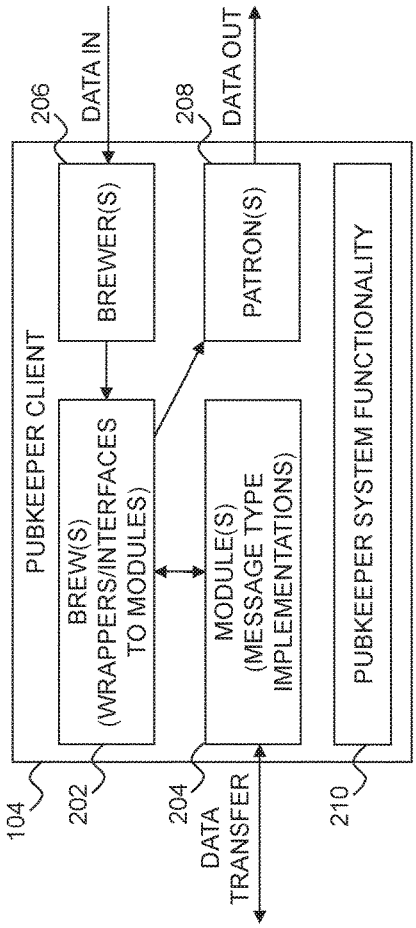


FIG. 2

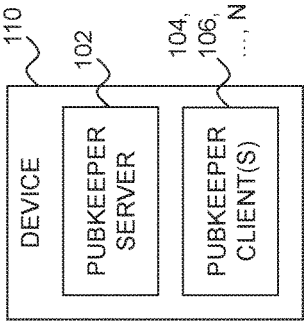


FIG. 1B

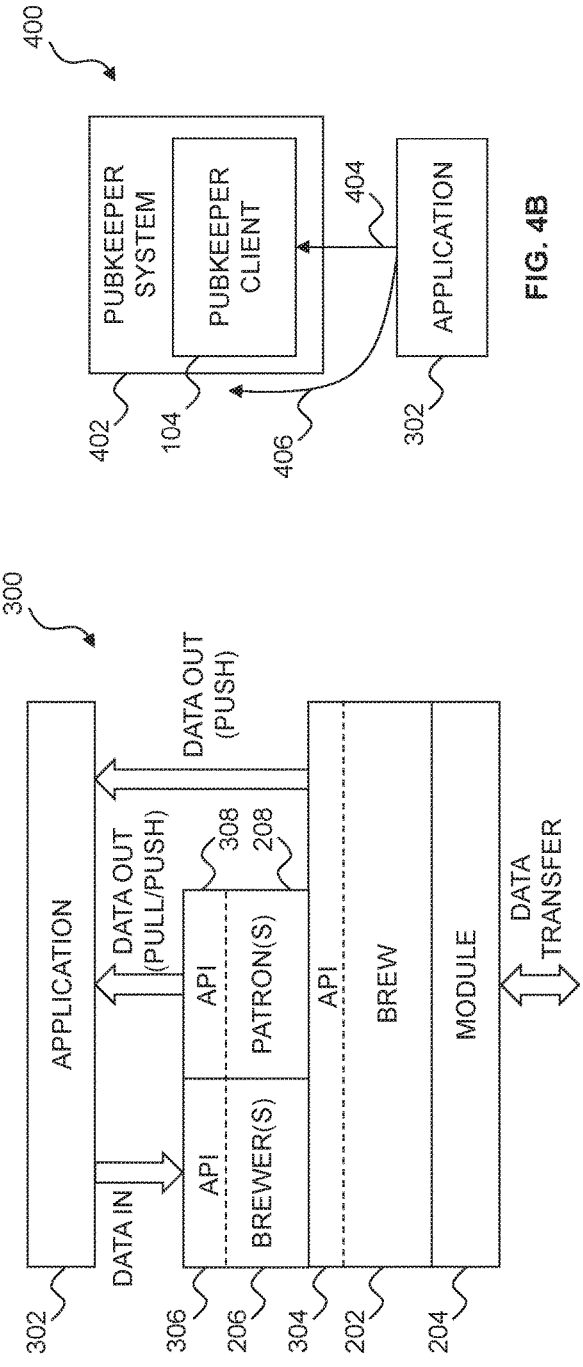


FIG. 4B

FIG. 3A

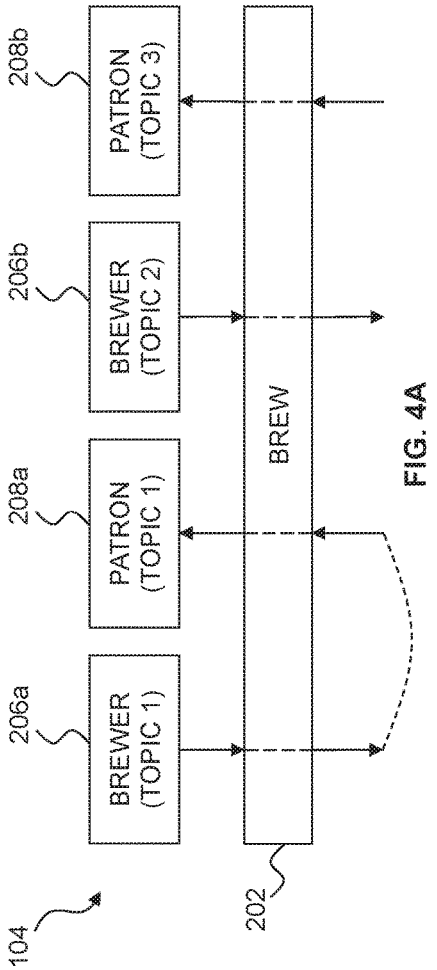


FIG. 4A

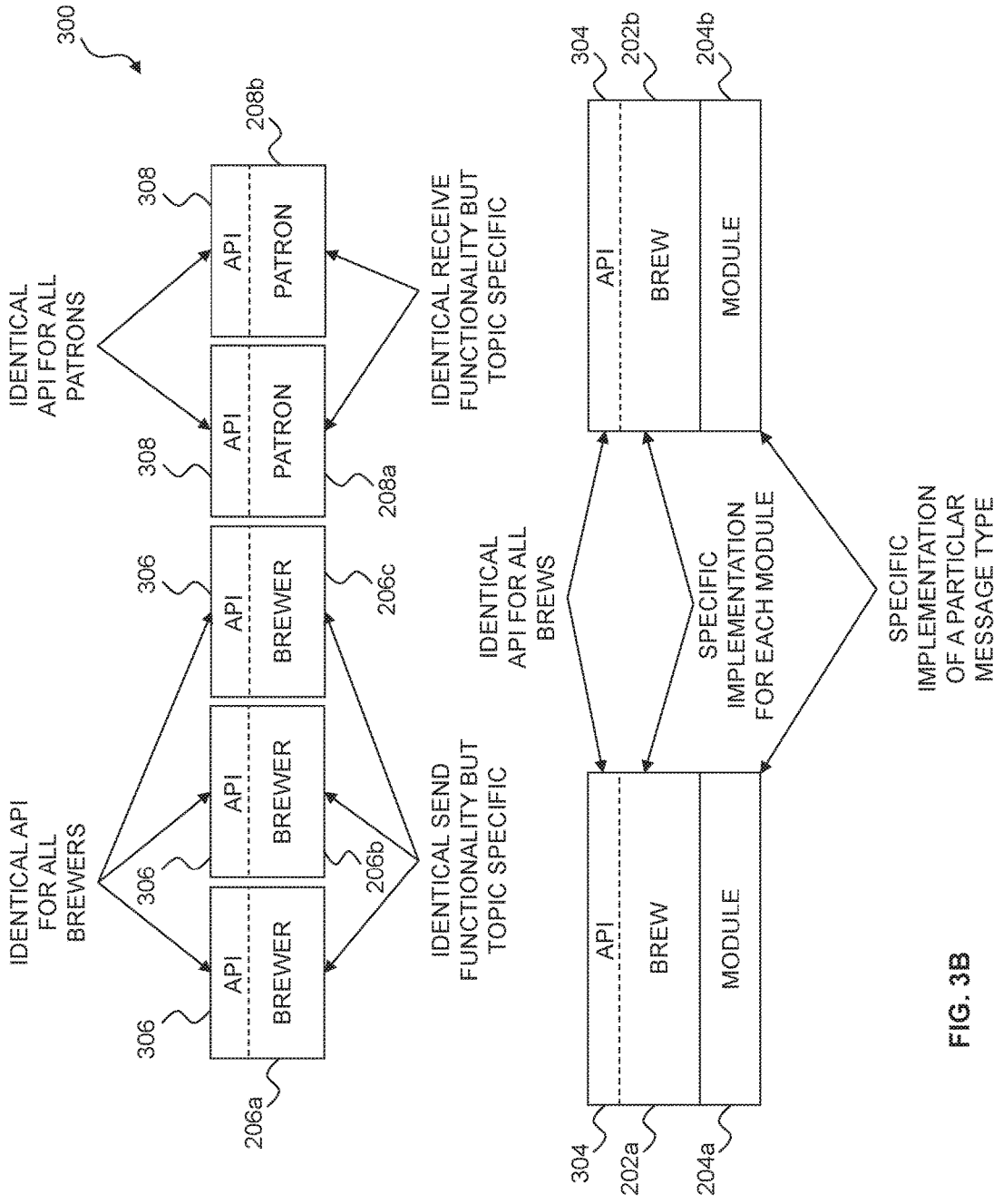

300
IDENTICAL API FOR ALL BREWERS
IDENTICAL API FOR ALL PATRONS
IDENTICAL SEND FUNCTIONALITY BUT TOPIC SPECIFIC
IDENTICAL RECEIVE FUNCTIONALITY BUT TOPIC SPECIFIC
IDENTICAL API FOR ALL BREWS
SPECIFIC IMPLEMENTATION FOR EACH MODULE
SPECIFIC IMPLEMENTATION OF A PARTICLAR MESSAGE TYPE
API
BREWER
PATRON
BREW
MODULE
306
308
206a
206b
206c
208a
208b
304
202a
202b
204a
204b

FIG. 3B

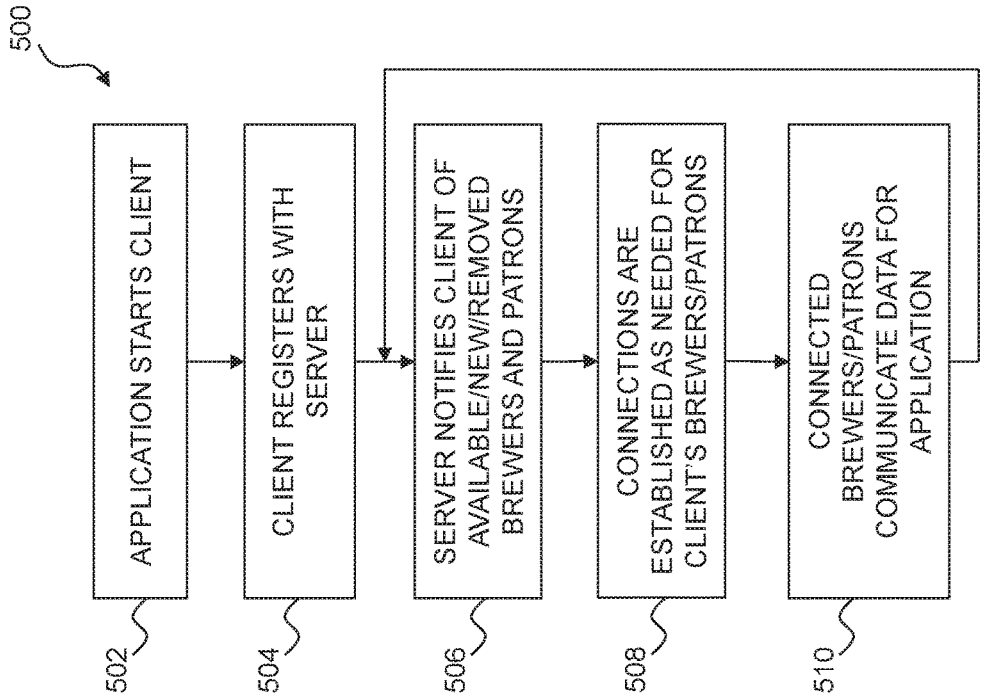

500
APPLICATION STARTS CLIENT
CLIENT REGISTERS WITH SERVER
SERVER NOTIFIES CLIENT OF AVAILABLE/NEW/REMOVED BREWERS AND PATRONS
CONNECTIONS ARE ESTABLISHED AS NEEDED FOR CLIENT'S BREWERS/PATRONS
CONNECTED BREWERS/PATRONS COMMUNICATE DATA FOR APPLICATION
502
504
506
508
510

FIG. 5

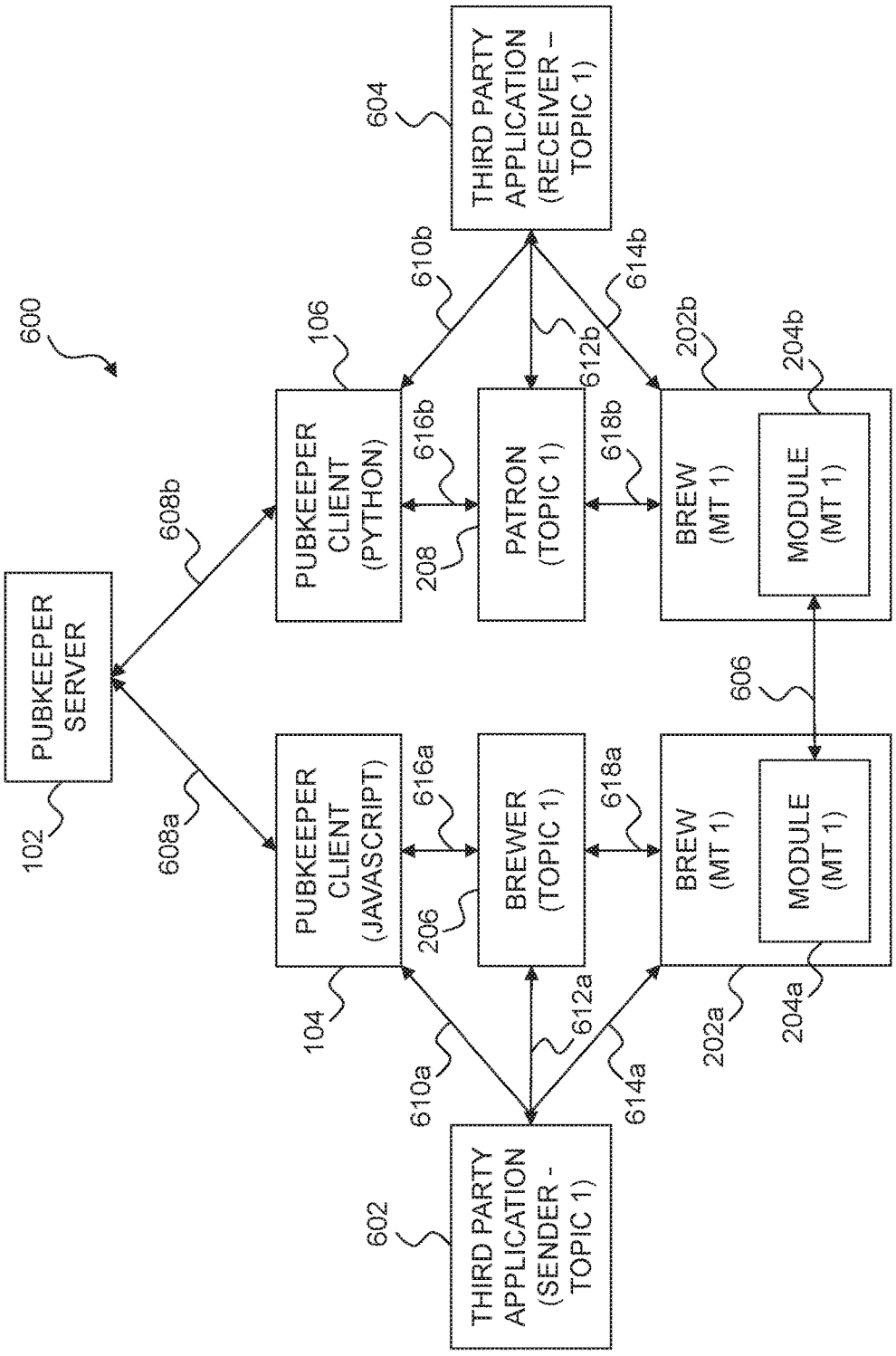

600
PUBKEEPER SERVER
102
608a
608b
PUBKEEPER CLIENT (JAVASCRIPT)
104
PUBKEEPER CLIENT (PYTHON)
106
616a
616b
206
208
BREWER (TOPIC 1)
PATRON (TOPIC 1)
618a
618b
BREW (MT 1)
BREW (MT 1)
MODULE (MT 1)
MODULE (MT 1)
202a
202b
204a
204b
606
610a
610b
612a
612b
614a
614b
THIRD PARTY APPLICATION (SENDER - TOPIC 1)
602
THIRD PARTY APPLICATION (RECEIVER – TOPIC 1)
604

FIG. 6

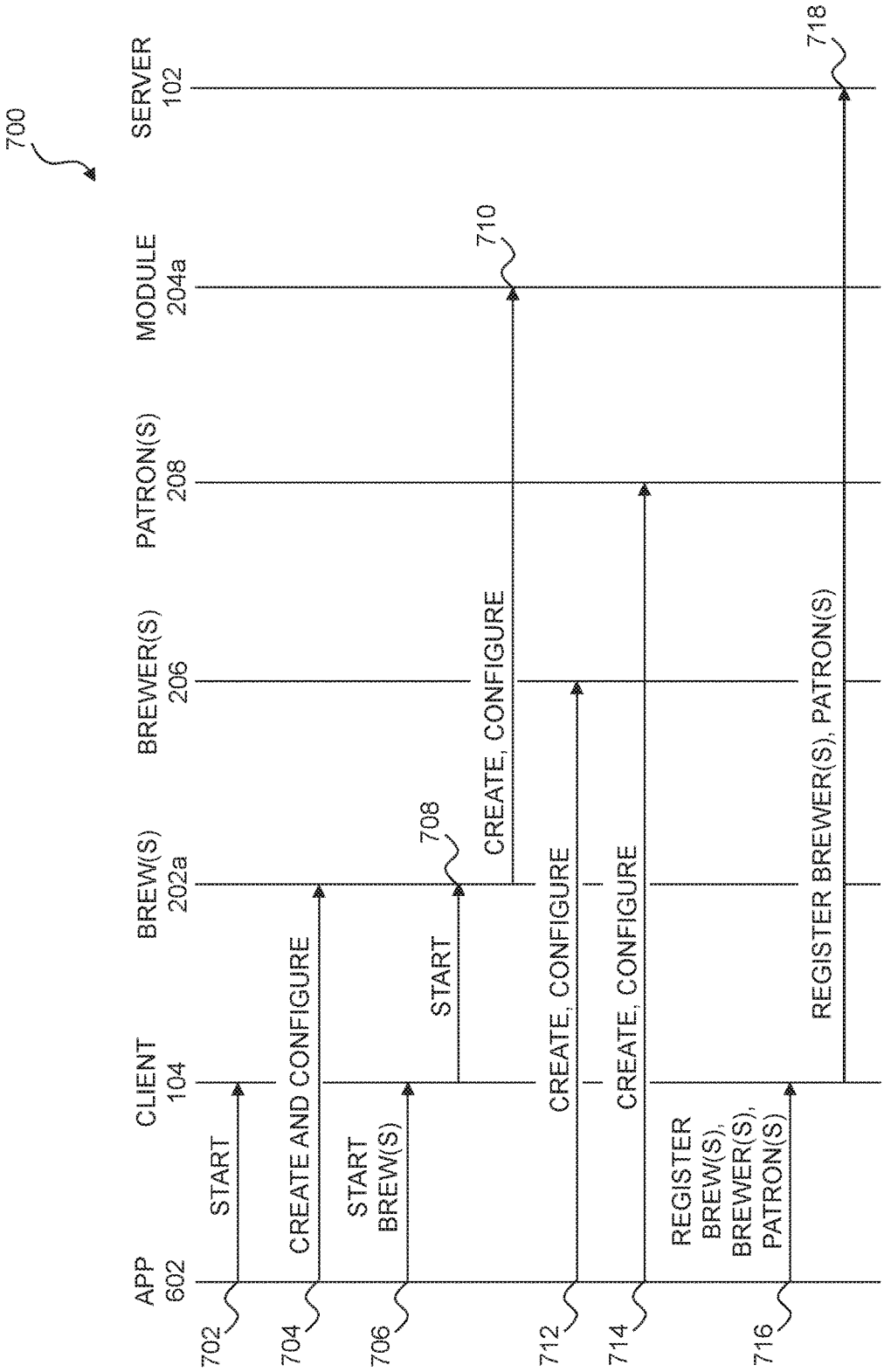

700
APP 602
CLIENT 104
BREW(S) 202a
BREWER(S) 206
PATRON(S) 208
MODULE 204a
SERVER 102
START
CREATE AND CONFIGURE
START BREW(S)
START
CREATE, CONFIGURE
CREATE, CONFIGURE
REGISTER BREW(S), BREWER(S), PATRON(S)
REGISTER BREWER(S), PATRON(S)
CREATE, CONFIGURE
702
704
706
708
710
712
714
716
718

FIG. 7

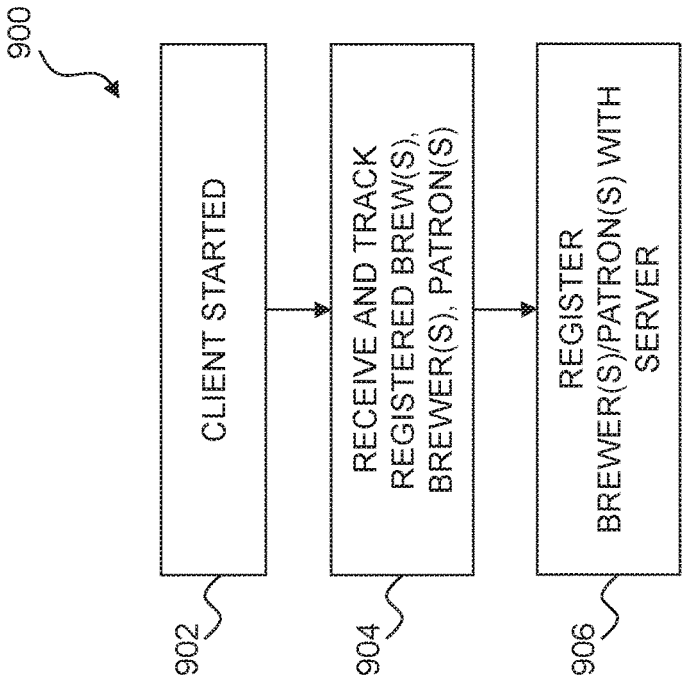

900
CLIENT STARTED
RECEIVE AND TRACK REGISTERED BREW(S), BREWER(S), PATRON(S)
REGISTER BREWER(S)/PATRON(S) WITH SERVER
902
904
906

FIG. 9

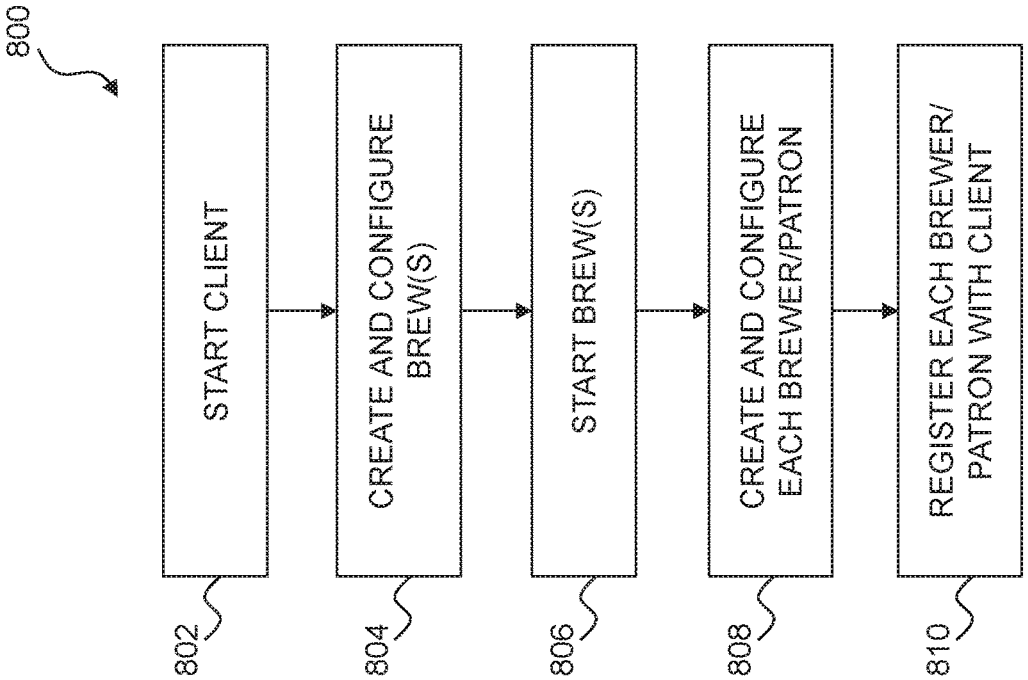

800
START CLIENT
CREATE AND CONFIGURE BREW(S)
START BREW(S)
CREATE AND CONFIGURE EACH BREWER/PATRON
REGISTER EACH BREWER/ PATRON WITH CLIENT
802
804
806
808
810

FIG. 8

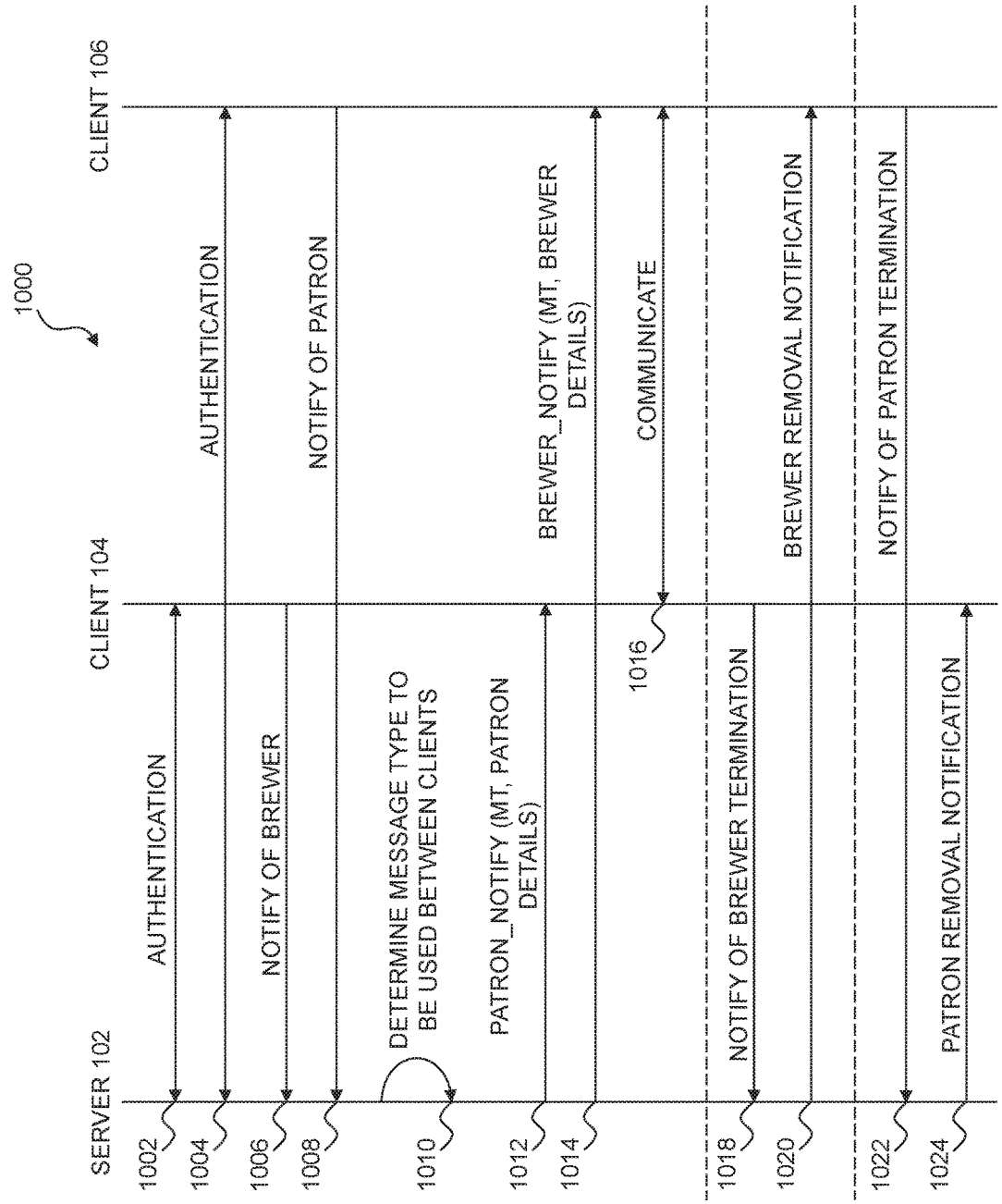

1000
SERVER 102
CLIENT 104
CLIENT 106
AUTHENTICATION
AUTHENTICATION
NOTIFY OF BREWER
NOTIFY OF PATRON
DETERMINE MESSAGE TYPE TO BE USED BETWEEN CLIENTS
PATRON_NOTIFY (MT, PATRON DETAILS)
BREWER_NOTIFY (MT, BREWER DETAILS)
COMMUNICATE
1016
NOTIFY OF BREWER TERMINATION
BREWER REMOVAL NOTIFICATION
NOTIFY OF PATRON TERMINATION
PATRON REMOVAL NOTIFICATION
1002
1004
1006
1008
1010
1012
1014
1018
1020
1022
1024

FIG. 10

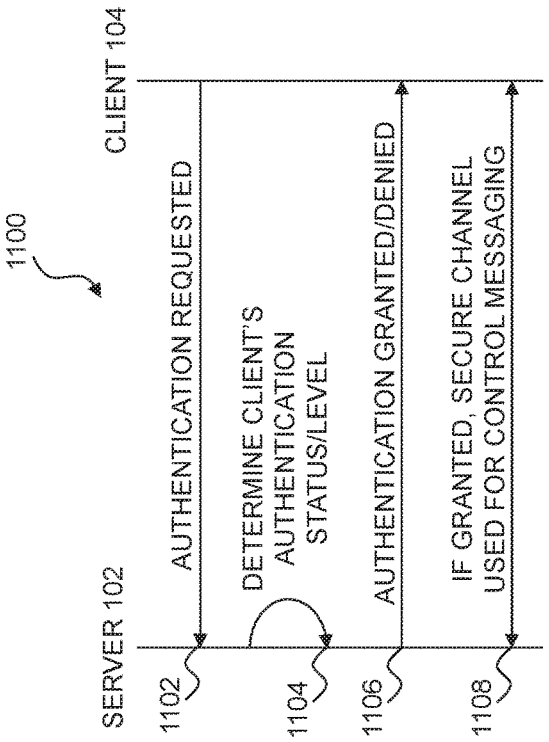

1100
SERVER 102
CLIENT 104
AUTHENTICATION REQUESTED
DETERMINE CLIENT'S AUTHENTICATION STATUS/LEVEL
AUTHENTICATION GRANTED/DENIED
IF GRANTED, SECURE CHANNEL USED FOR CONTROL MESSAGING
1102
1104
1106
1108

FIG. 11

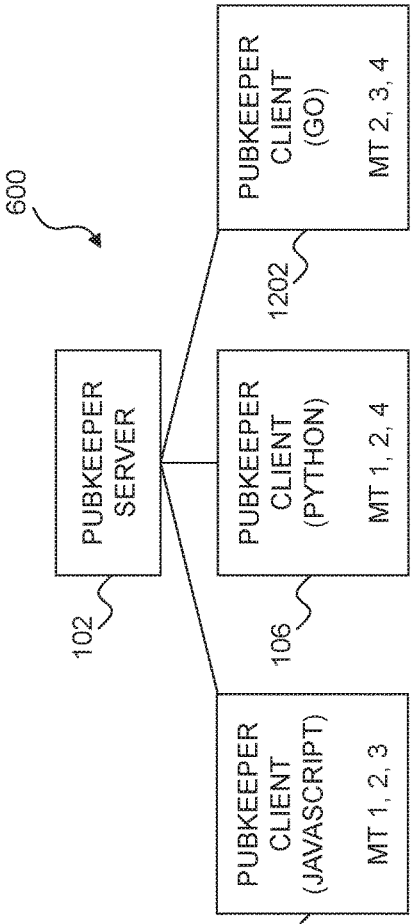

600
PUBKEEPER SERVER
102
PUBKEEPER CLIENT (JAVASCRIPT)
MT 1, 2, 3
104
PUBKEEPER CLIENT (PYTHON)
MT 1, 2, 4
106
PUBKEEPER CLIENT (GO)
MT 2, 3, 4
1202

FIG. 12

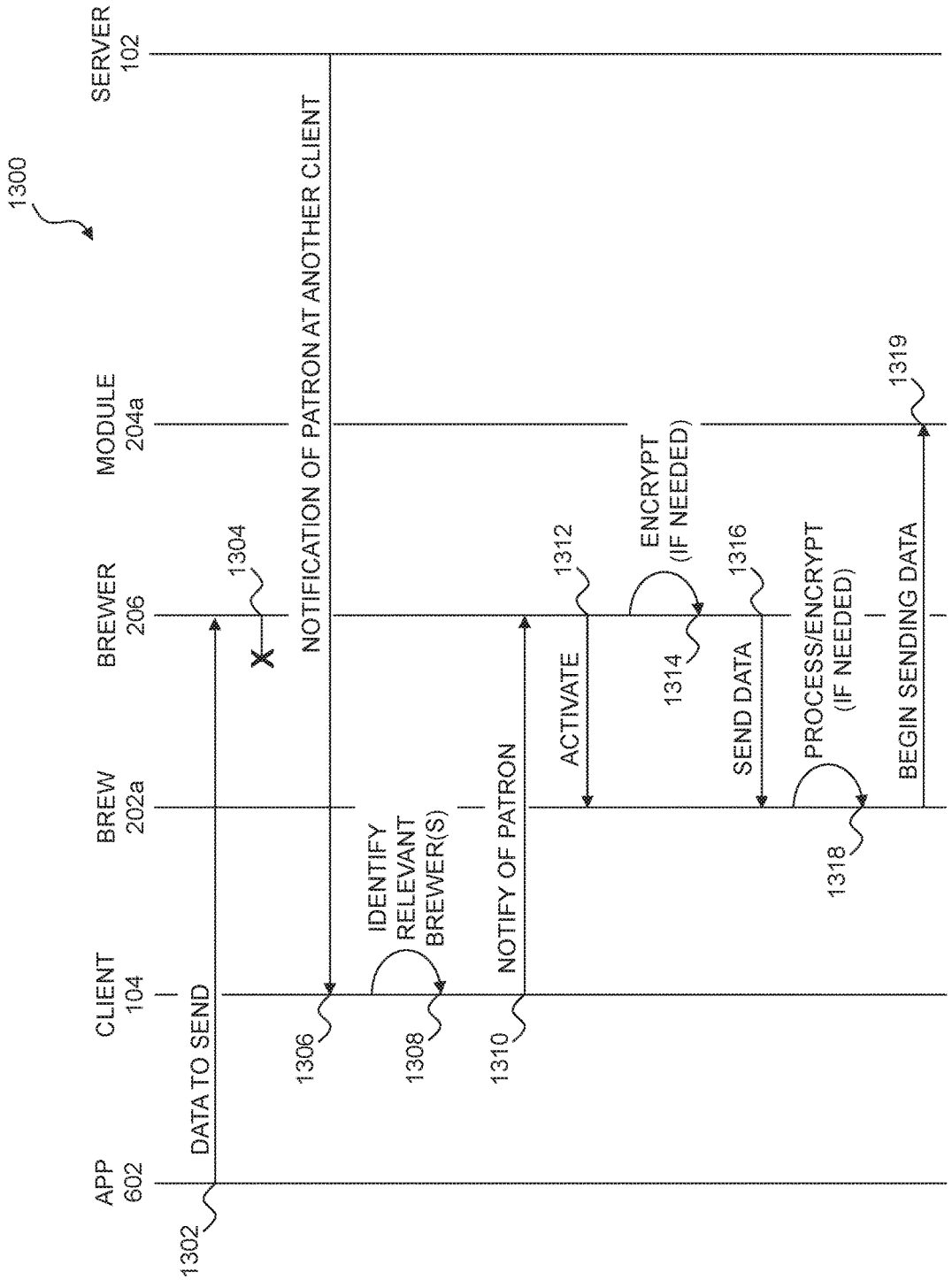

1300
APP 602
CLIENT 104
BREW 202a
BREWER 206
MODULE 204a
SERVER 102
DATA TO SEND
1302
1304
NOTIFICATION OF PATRON AT ANOTHER CLIENT
1306
IDENTIFY RELEVANT BREWER(S)
1308
NOTIFY OF PATRON
1310
1312
ACTIVATE
ENCRYPT (IF NEEDED)
1314
1316
SEND DATA
PROCESS/ENCRYPT (IF NEEDED)
1318
1319
BEGIN SENDING DATA

FIG. 13A

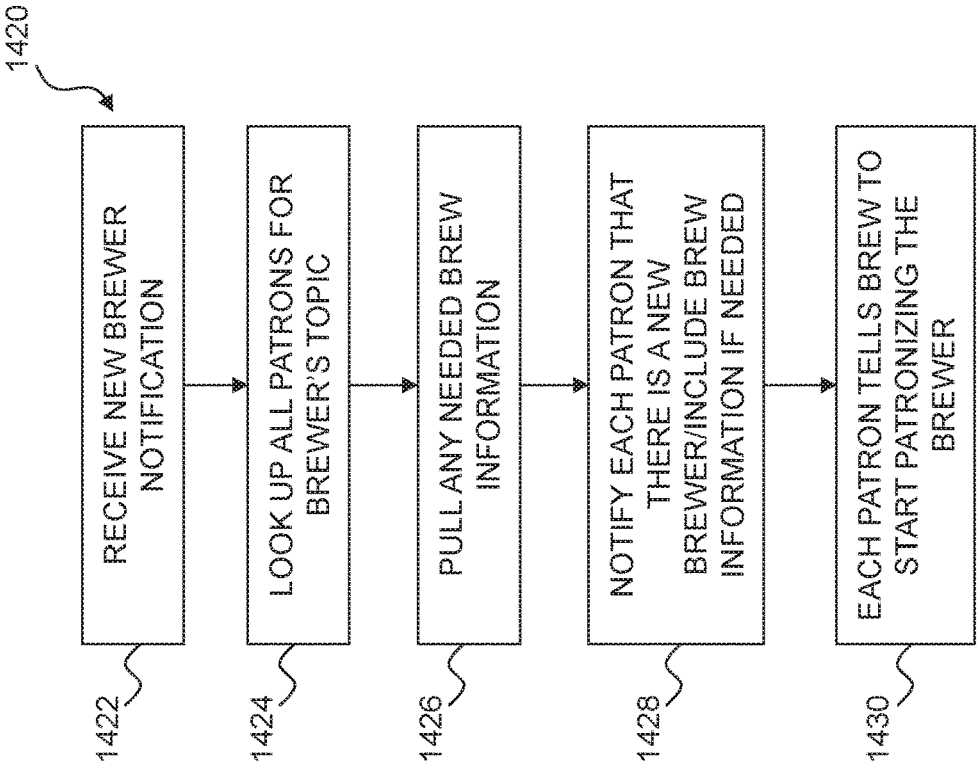


FIG. 14B

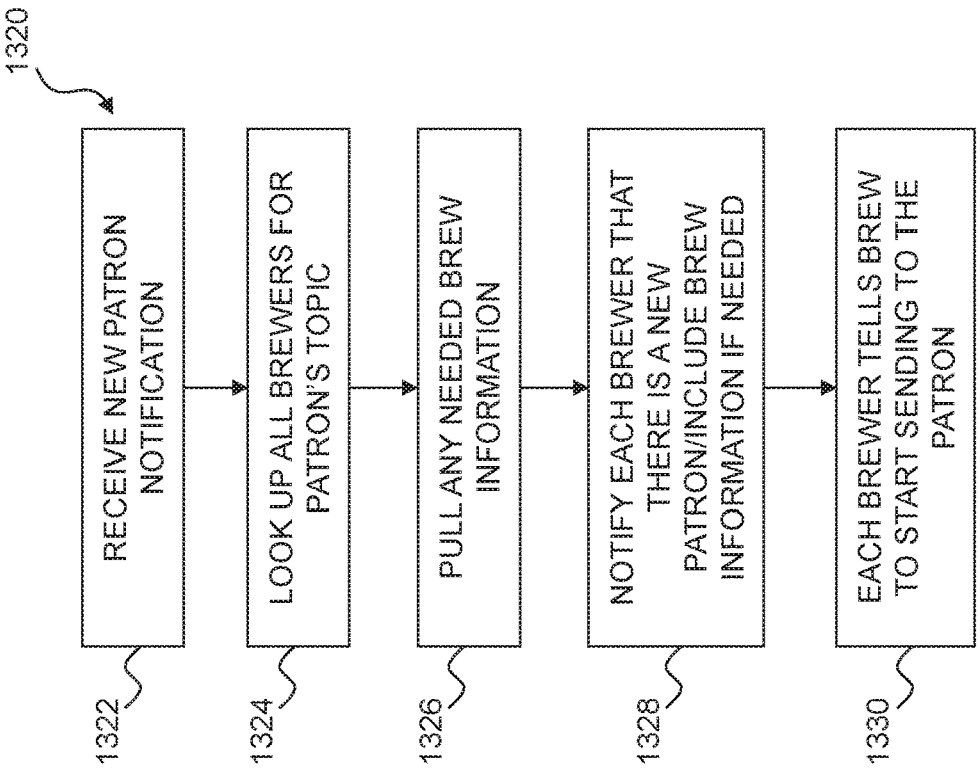


FIG. 13B

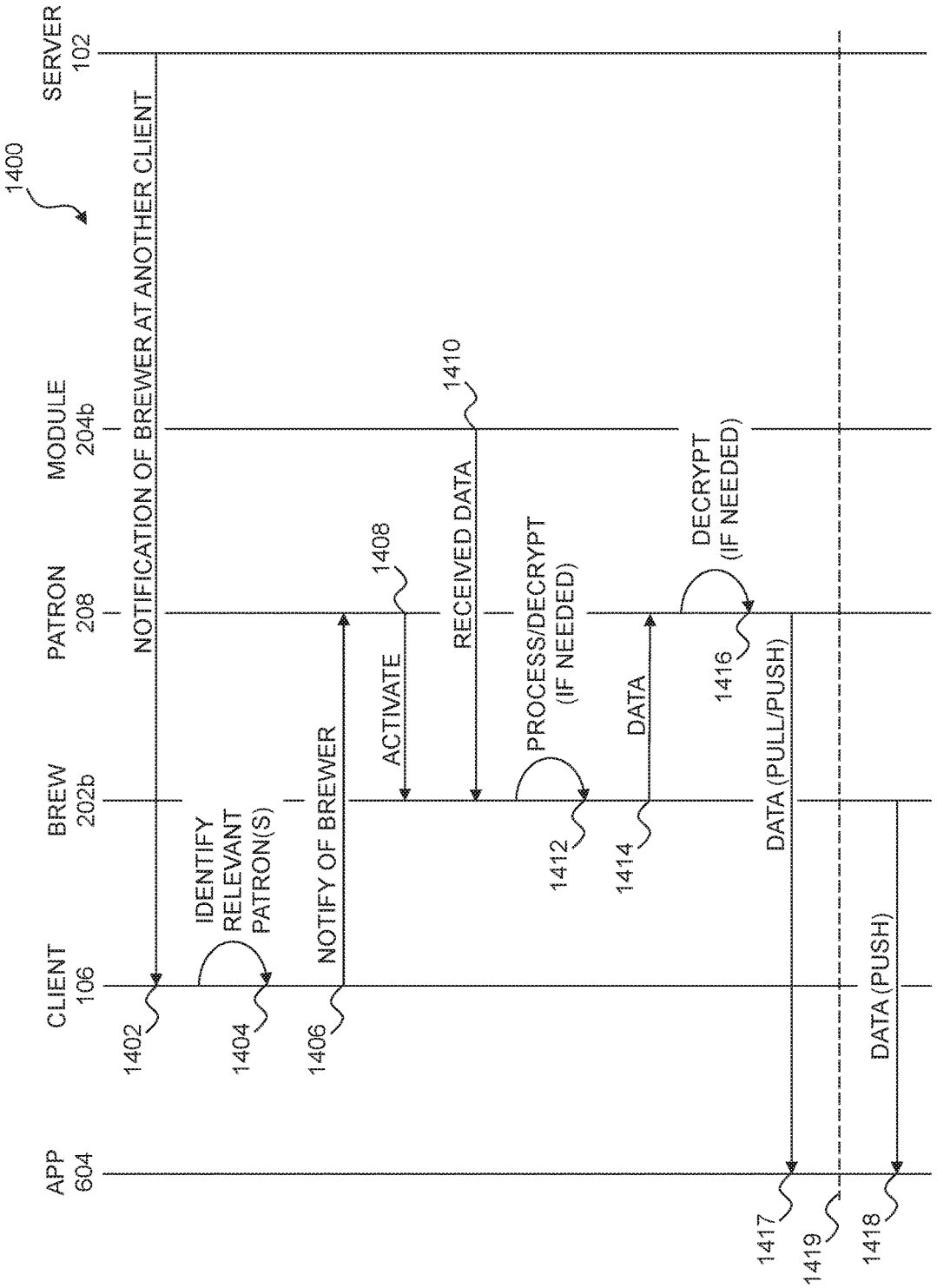

1400
SERVER 102
MODULE 204b
PATRON 208
BREW 202b
CLIENT 106
APP 604
NOTIFICATION OF BREWER AT ANOTHER CLIENT
IDENTIFY RELEVANT PATRON(S)
NOTIFY OF BREWER
ACTIVATE
RECEIVED DATA
PROCESS/DECRYPT (IF NEEDED)
DATA
DECRYPT (IF NEEDED)
DATA (PULL/PUSH)
DATA (PUSH)
1402
1404
1406
1408
1410
1412
1414
1416
1417
1419
1418

FIG. 14A

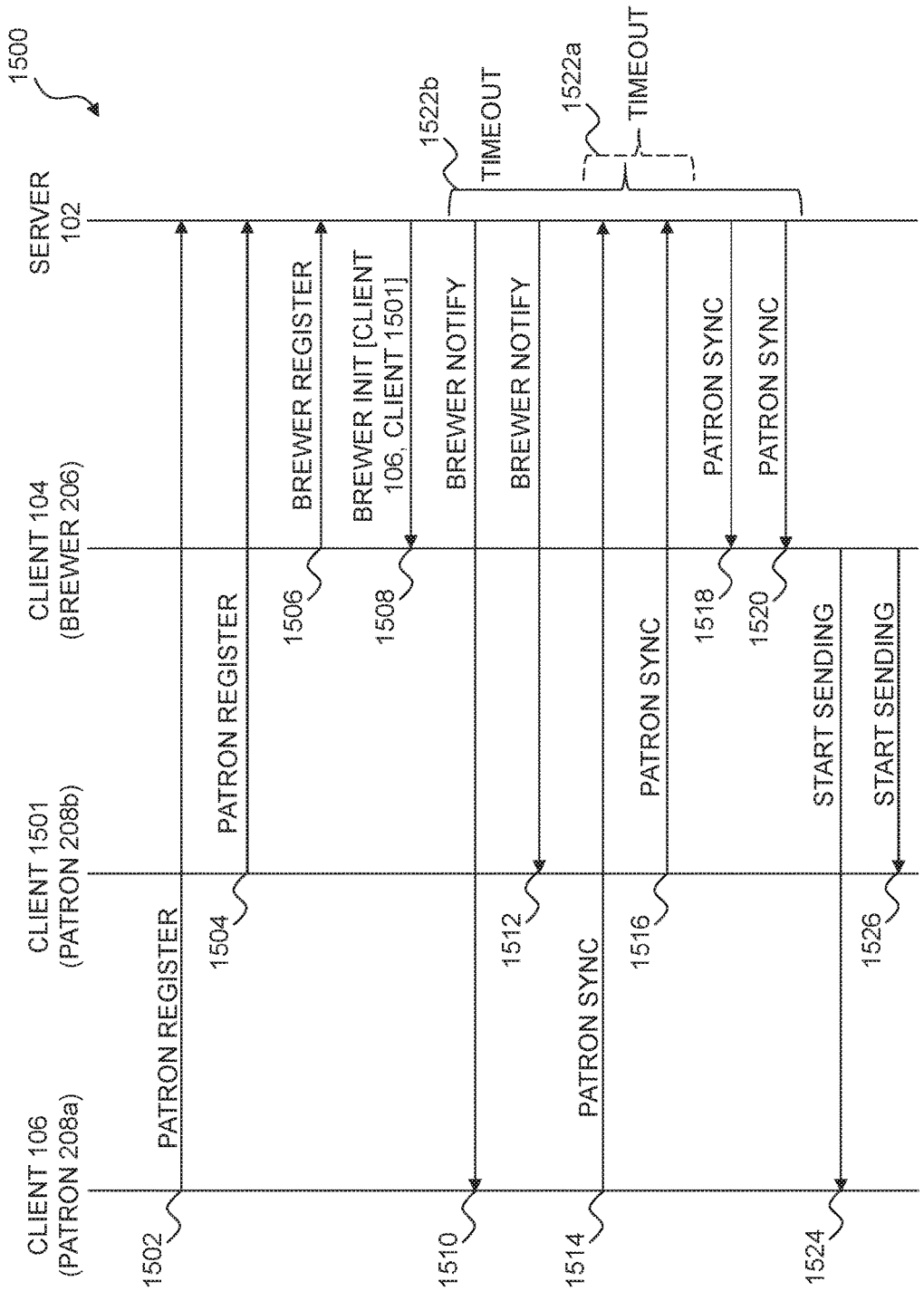

1500
CLIENT 106 (PATRON 208a)
CLIENT 1501 (PATRON 208b)
CLIENT 104 (BREWER 206)
SERVER 102
PATRON REGISTER
PATRON REGISTER
BREWER REGISTER
BREWER INIT [CLIENT 106, CLIENT 1501]
BREWER NOTIFY
BREWER NOTIFY
PATRON SYNC
PATRON SYNC
PATRON SYNC
START SENDING
START SENDING
1522b
TIMEOUT
1522a
TIMEOUT
1502
1504
1506
1508
1510
1512
1514
1516
1518
1520
1524
1526

FIG. 15

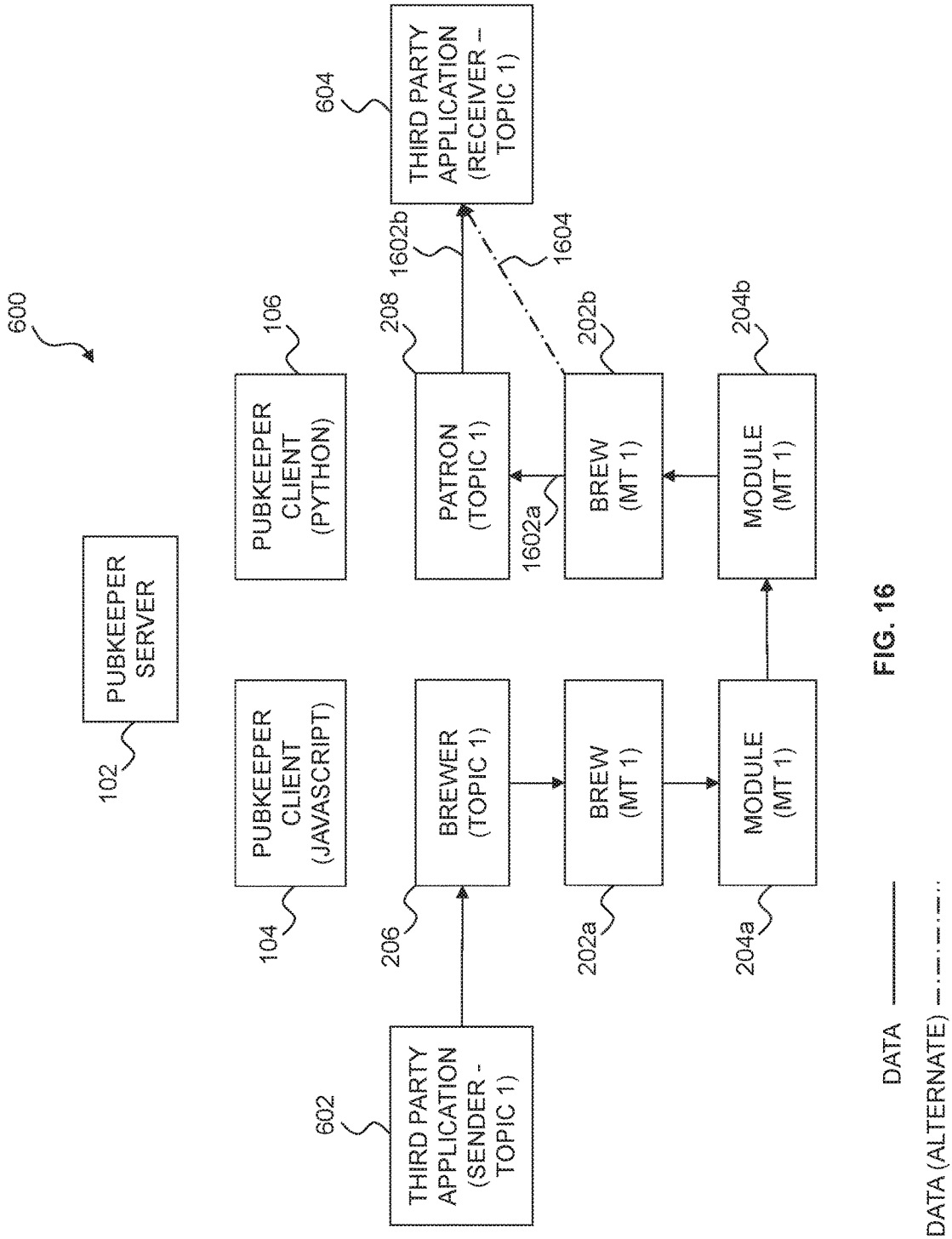

600
PUBKEEPER SERVER
102
PUBKEEPER CLIENT (JAVASCRIPT)
104
PUBKEEPER CLIENT (PYTHON)
106
THIRD PARTY APPLICATION (SENDER - TOPIC 1)
602
BREWER (TOPIC 1)
206
BREW (MT 1)
202a
MODULE (MT 1)
204a
PATRON (TOPIC 1)
208
BREW (MT 1)
202b
MODULE (MT 1)
204b
THIRD PARTY APPLICATION (RECEIVER – TOPIC 1)
604
1602a
1602b
1604
DATA
DATA (ALTERNATE)

FIG. 16

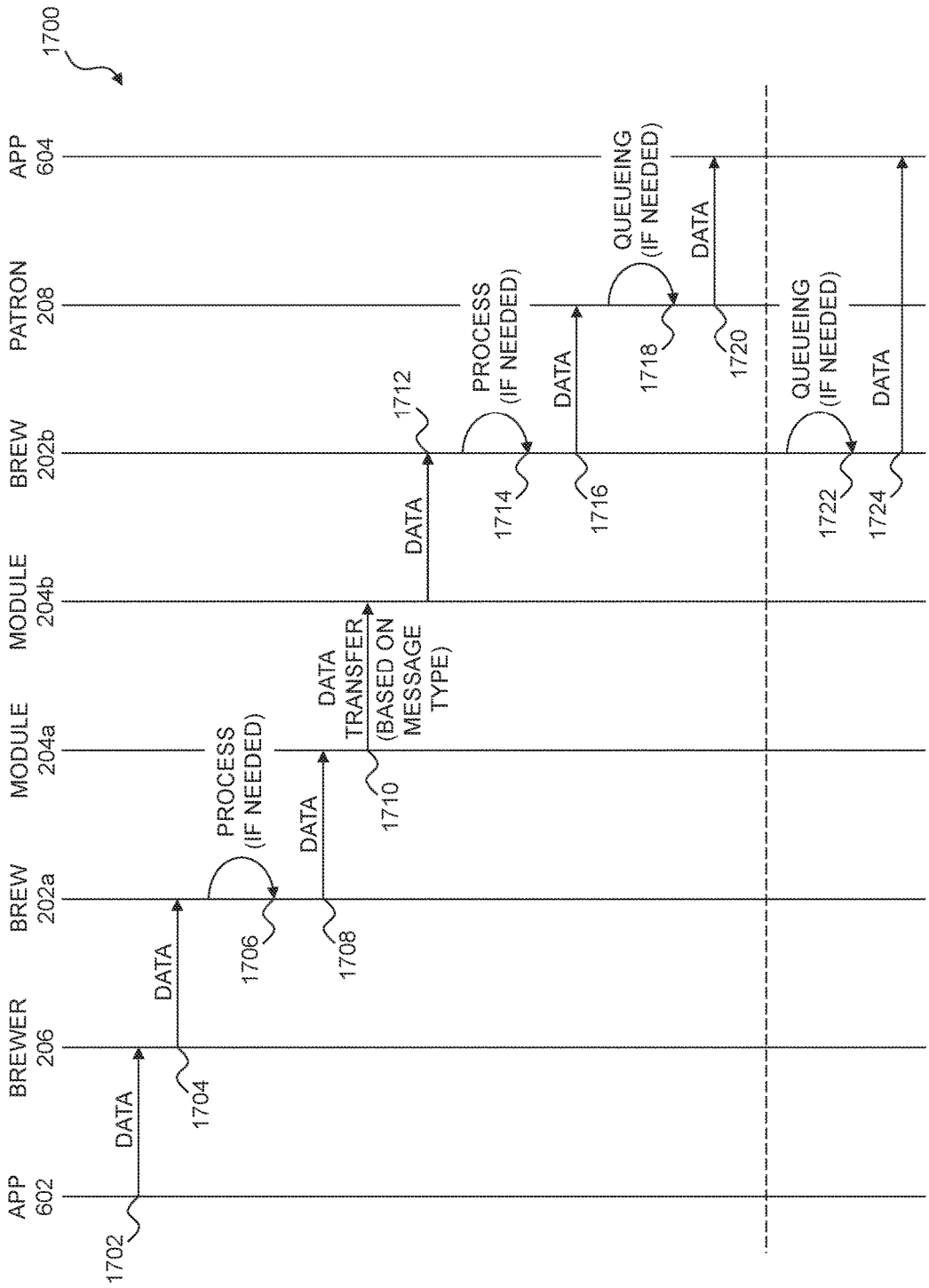

1700
APP 602
BREWER 206
BREW 202a
MODULE 204a
MODULE 204b
BREW 202b
PATRON 208
APP 604
1702
DATA
1704
DATA
1706
PROCESS (IF NEEDED)
1708
DATA
1710
DATA TRANSFER (BASED ON MESSAGE TYPE)
1712
DATA
1714
PROCESS (IF NEEDED)
1716
DATA
1718
QUEUEING (IF NEEDED)
1720
DATA
1722
QUEUEING (IF NEEDED)
1724
DATA

FIG. 17

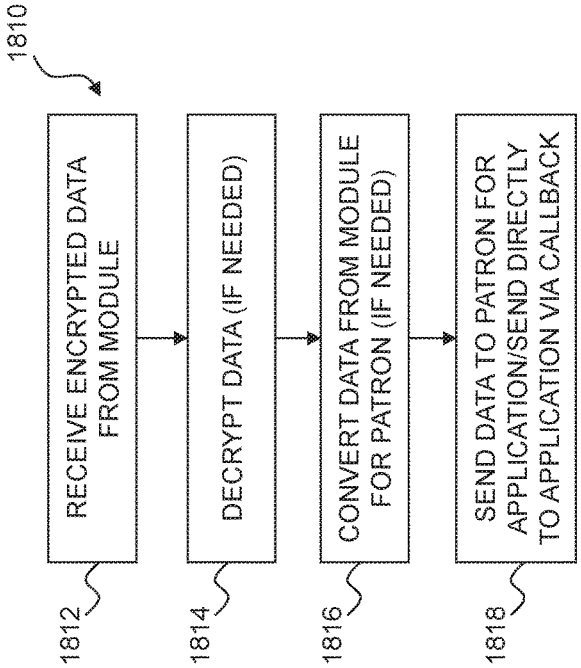


FIG. 18B

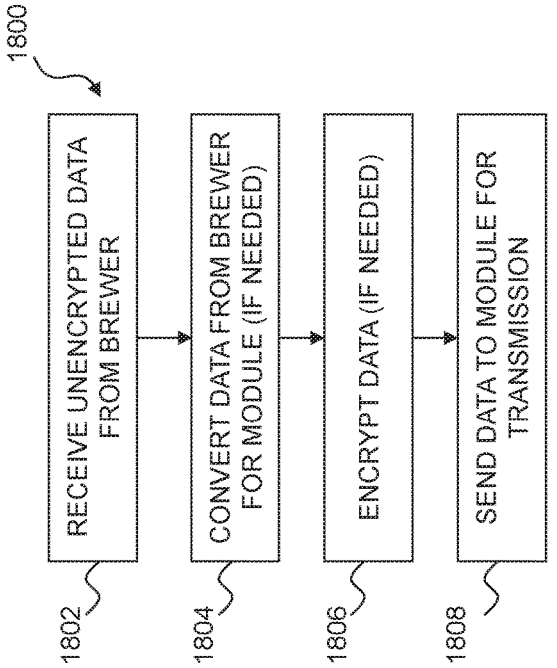


FIG. 18A

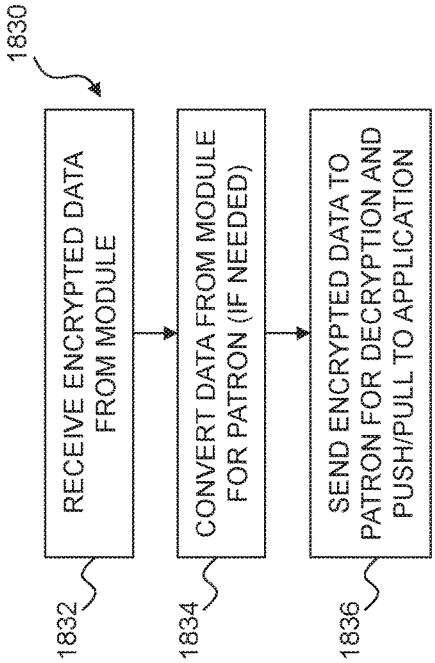


FIG. 18D

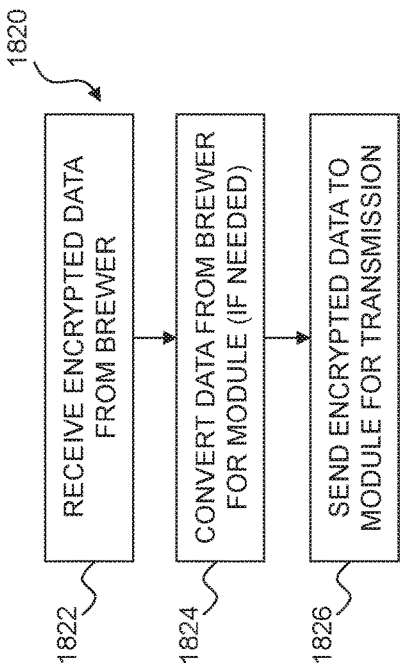


FIG. 18C

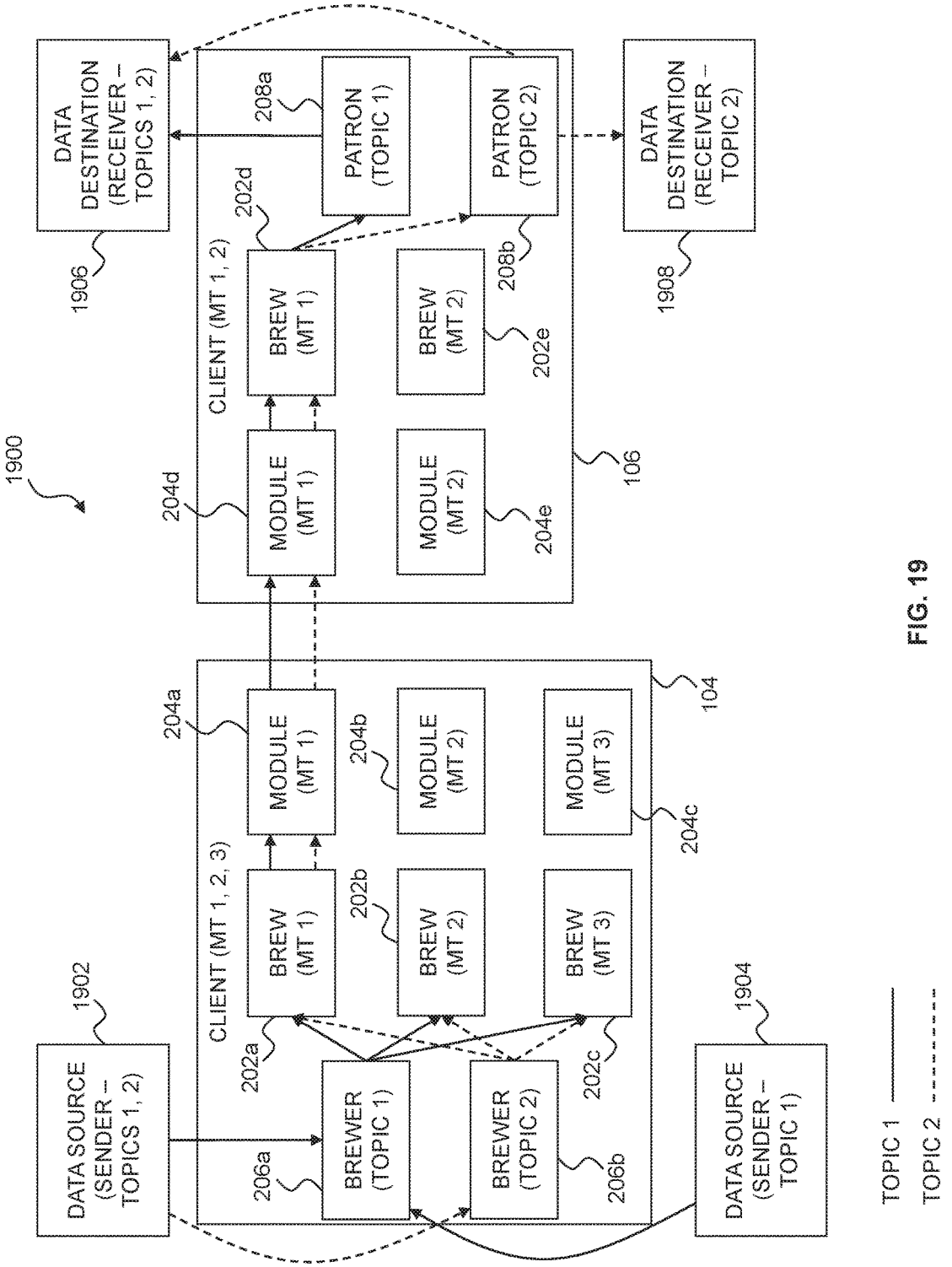

1900
DATA SOURCE (SENDER – TOPICS 1, 2)
1902
DATA SOURCE (SENDER – TOPIC 1)
1904
DATA DESTINATION (RECEIVER – TOPICS 1, 2)
1906
DATA DESTINATION (RECEIVER – TOPIC 2)
1908
CLIENT (MT 1, 2, 3)
104
CLIENT (MT 1, 2)
106
BREWER (TOPIC 1)
206a
BREWER (TOPIC 2)
206b
BREW (MT 1)
202a
BREW (MT 2)
202b
BREW (MT 3)
202c
BREW (MT 1)
202d
BREW (MT 2)
202e
MODULE (MT 1)
204a
MODULE (MT 2)
204b
MODULE (MT 3)
204c
MODULE (MT 1)
204d
MODULE (MT 2)
204e
PATRON (TOPIC 1)
208a
PATRON (TOPIC 2)
208b
TOPIC 1
TOPIC 2

FIG. 19

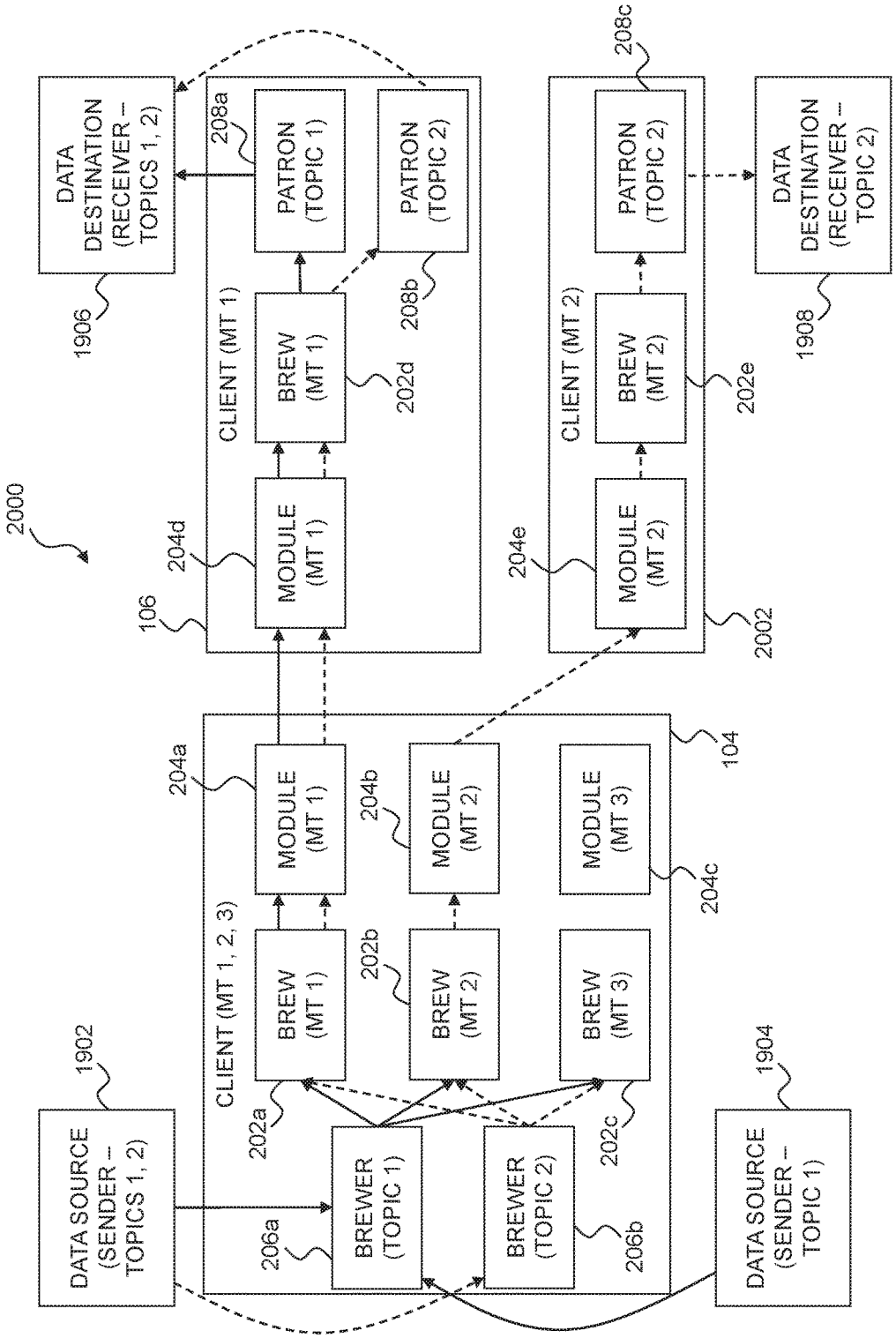

2000
DATA SOURCE (SENDER – TOPICS 1, 2)
1902
DATA SOURCE (SENDER – TOPIC 1)
1904
DATA DESTINATION (RECEIVER – TOPICS 1, 2)
1906
DATA DESTINATION (RECEIVER – TOPIC 2)
1908
CLIENT (MT 1, 2, 3)
104
CLIENT (MT 1)
106
CLIENT (MT 2)
2002
BREWER (TOPIC 1)
206a
BREWER (TOPIC 2)
206b
BREW (MT 1)
202a
BREW (MT 2)
202b
BREW (MT 3)
202c
BREW (MT 1)
202d
BREW (MT 2)
202e
MODULE (MT 1)
204a
MODULE (MT 2)
204b
MODULE (MT 3)
204c
MODULE (MT 1)
204d
MODULE (MT 2)
204e
PATRON (TOPIC 1)
208a
PATRON (TOPIC 2)
208b
PATRON (TOPIC 2)
208c
TOPIC 1
TOPIC 2

FIG. 20

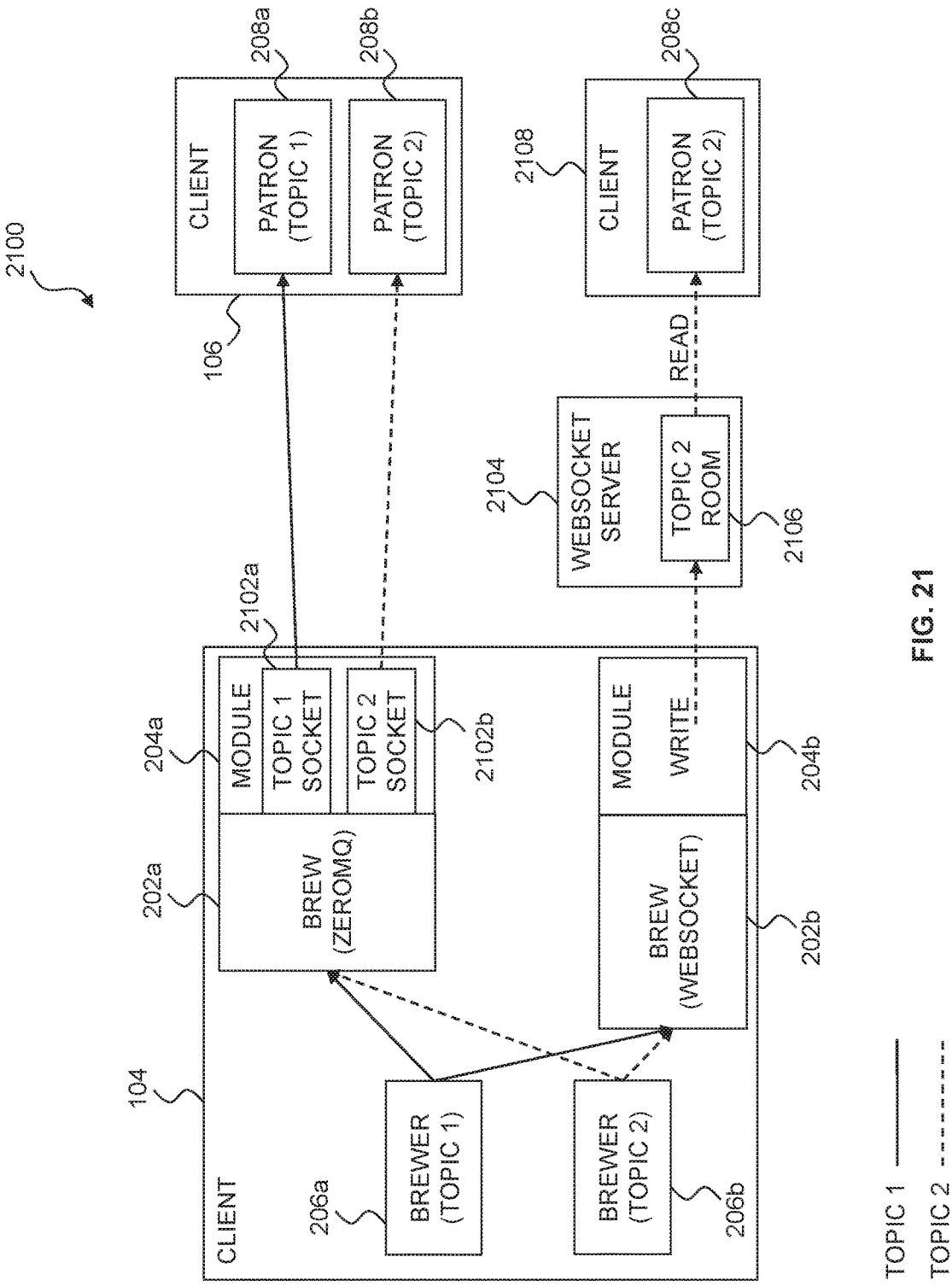

2100
CLIENT
PATRON (TOPIC 1)
PATRON (TOPIC 2)
208a
208b
106
2108
CLIENT
PATRON (TOPIC 2)
208c
READ
2104
WEBSOCKET SERVER
TOPIC 2 ROOM
2106
2102a
MODULE
TOPIC 1 SOCKET
TOPIC 2 SOCKET
2102b
204a
202a
BREW (ZEROMQ)
MODULE
WRITE
204b
BREW (WEBSOCKET)
202b
104
CLIENT
206a
BREWER (TOPIC 1)
BREWER (TOPIC 2)
206b
TOPIC 1
TOPIC 2

FIG. 21

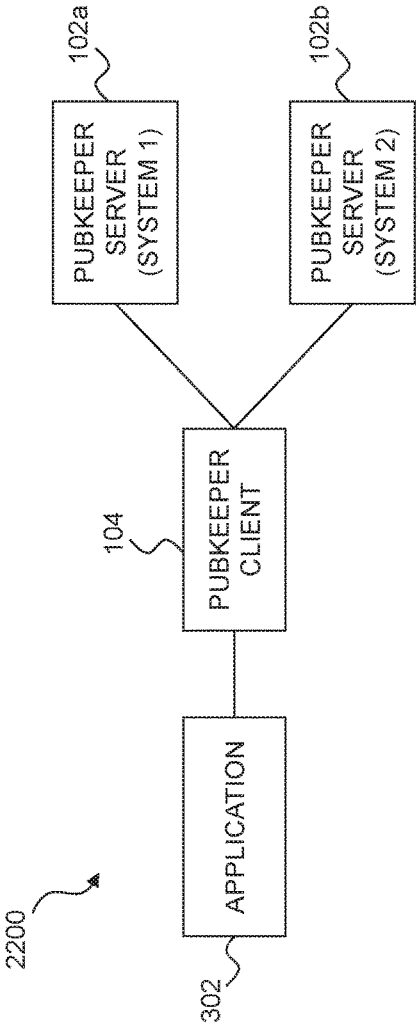

2200
APPLICATION
302
PUBKEEPER CLIENT
104
PUBKEEPER SERVER (SYSTEM 1)
102a
PUBKEEPER SERVER (SYSTEM 2)
102b

FIG. 22

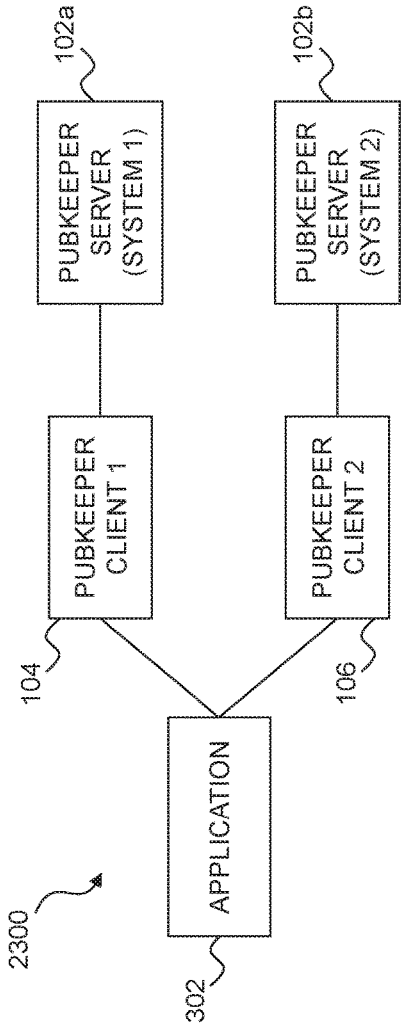

2300
APPLICATION
302
PUBKEEPER CLIENT 1
104
PUBKEEPER CLIENT 2
106
PUBKEEPER SERVER (SYSTEM 1)
102a
PUBKEEPER SERVER (SYSTEM 2)
102b

FIG. 23

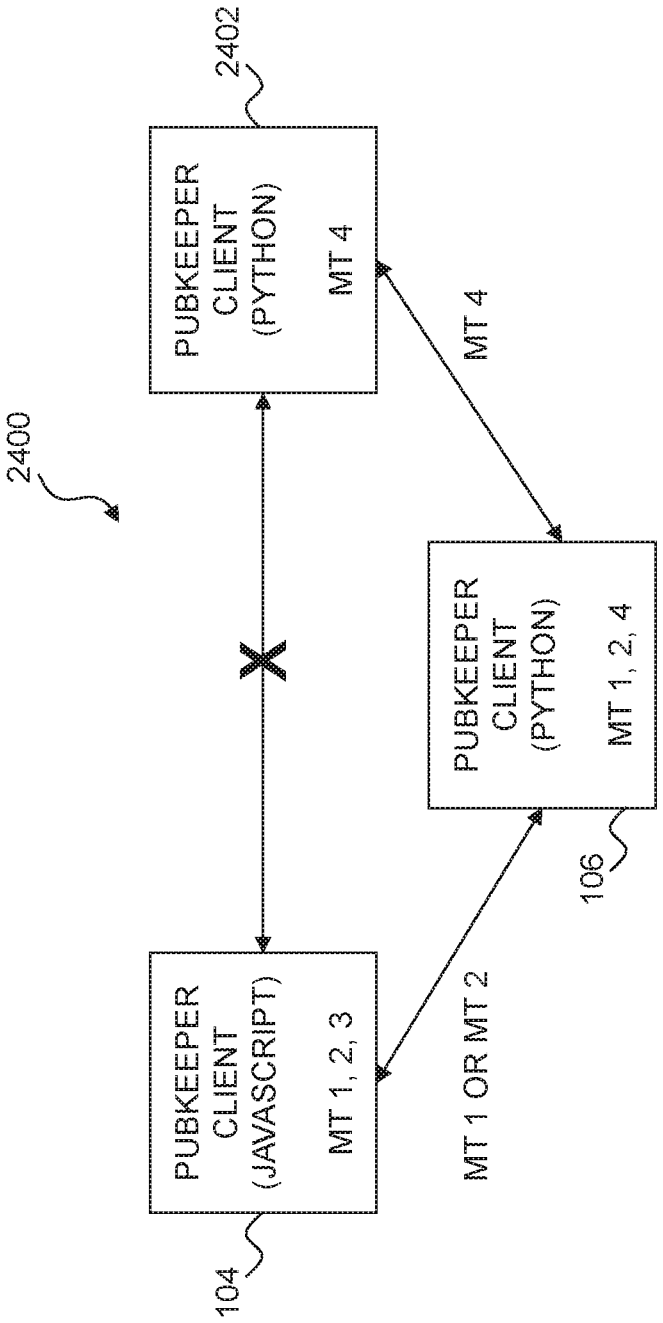

2400
2402
PUBKEEPER CLIENT (PYTHON) MT 4
MT 4
PUBKEEPER CLIENT (PYTHON) MT 1, 2, 4
106
PUBKEEPER CLIENT (JAVASCRIPT) MT 1, 2, 3
MT 1 OR MT 2
104

FIG. 24

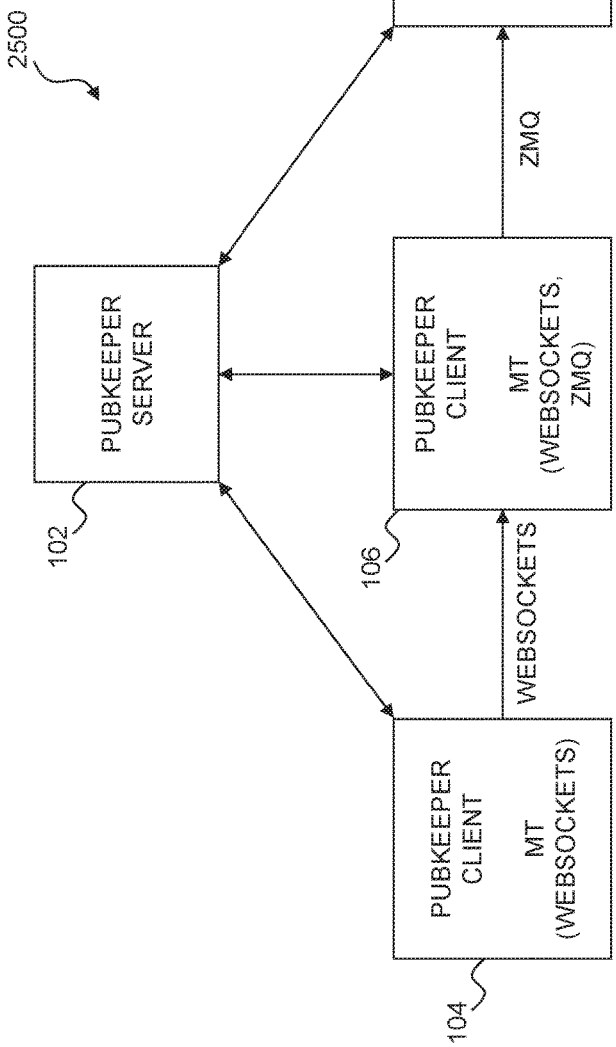


FIG. 25A

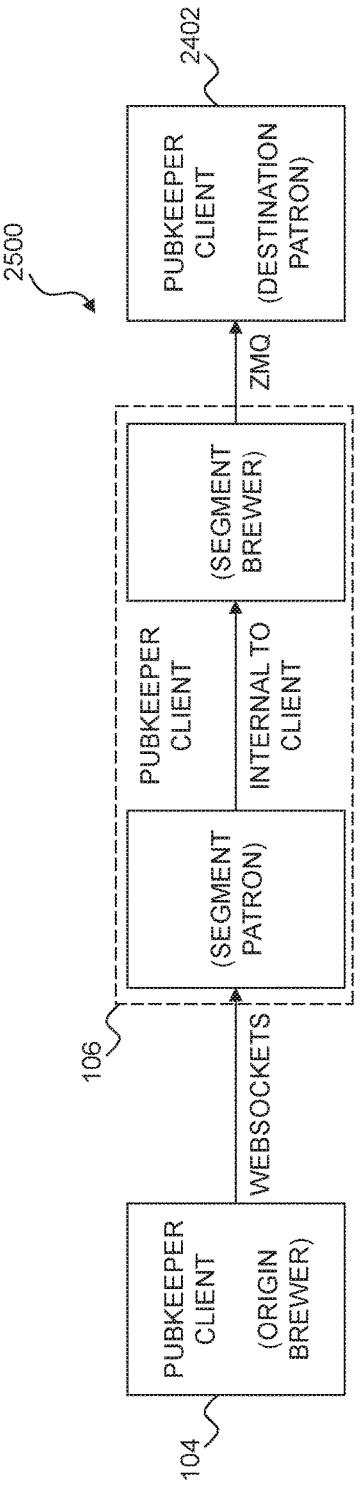


FIG. 25B

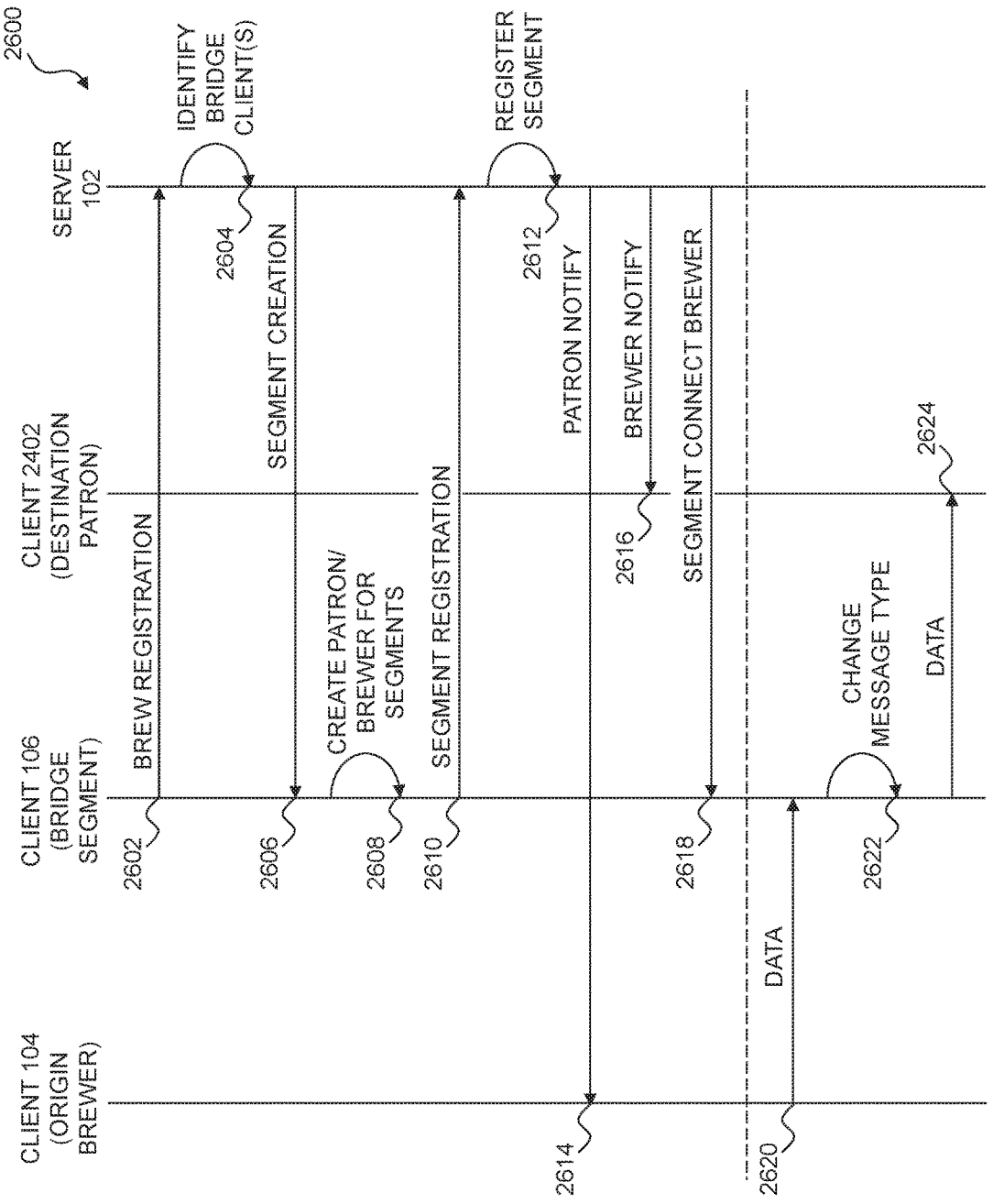

2600
SERVER 102
CLIENT 2402 (DESTINATION PATRON)
CLIENT 106 (BRIDGE SEGMENT)
CLIENT 104 (ORIGIN BREWER)
IDENTIFY BRIDGE CLIENT(S)
2604
REGISTER SEGMENT
2612
BREW REGISTRATION
2602
SEGMENT CREATION
2606
CREATE PATRON/ BREWER FOR SEGMENTS
2608
SEGMENT REGISTRATION
2610
PATRON NOTIFY
2614
BREWER NOTIFY
2616
SEGMENT CONNECT BREWER
2618
DATA
2620
CHANGE MESSAGE TYPE
2622
DATA
2624

FIG. 26

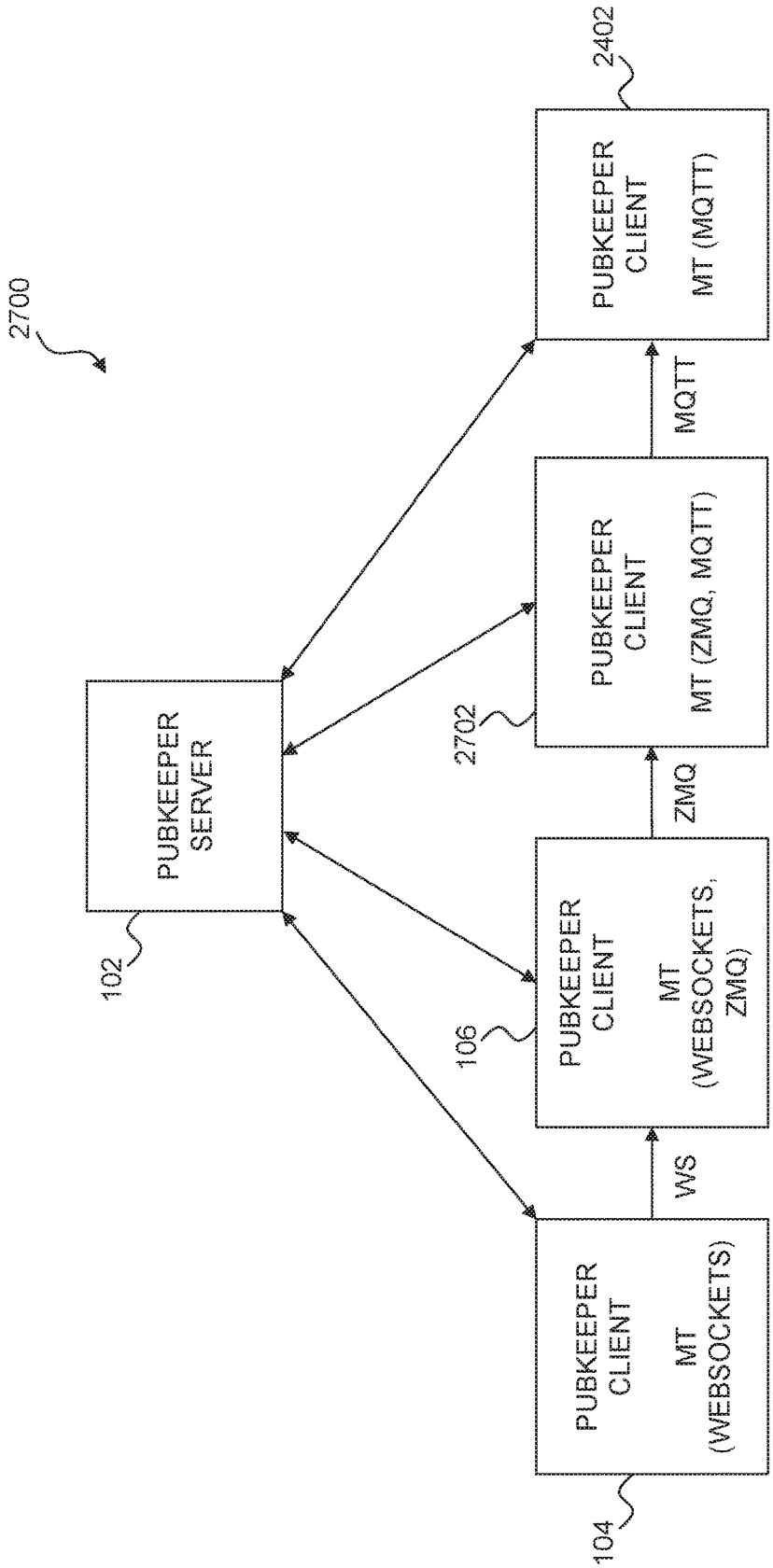

2700
PUBKEEPER SERVER
102
PUBKEEPER CLIENT
MT (WEBSOCKETS)
104
WS
PUBKEEPER CLIENT
MT (WEBSOCKETS, ZMQ)
106
ZMQ
PUBKEEPER CLIENT
MT (ZMQ, MQTT)
2702
MQTT
PUBKEEPER CLIENT
MT (MQTT)
2402

FIG. 27

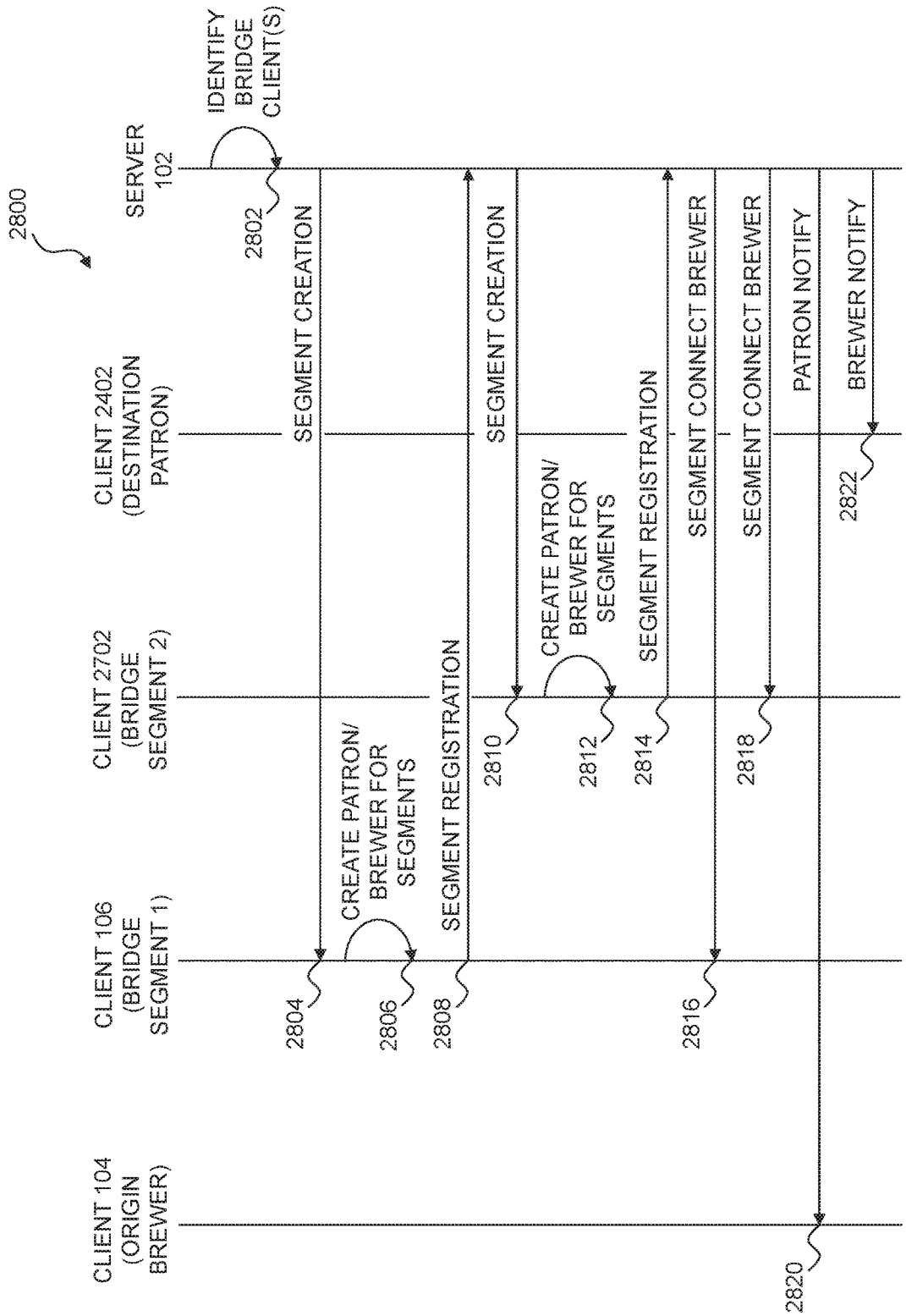

2800
SERVER 102
CLIENT 2402 (DESTINATION PATRON)
CLIENT 2702 (BRIDGE SEGMENT 2)
CLIENT 106 (BRIDGE SEGMENT 1)
CLIENT 104 (ORIGIN BREWER)
IDENTIFY BRIDGE CLIENT(S)
2802
SEGMENT CREATION
SEGMENT CREATION
CREATE PATRON/ BREWER FOR SEGMENTS
SEGMENT REGISTRATION
SEGMENT CONNECT BREWER
SEGMENT CONNECT BREWER
PATRON NOTIFY
BREWER NOTIFY
2822
CREATE PATRON/ BREWER FOR SEGMENTS
SEGMENT REGISTRATION
2804
2806
2808
2810
2812
2814
2816
2818
2820

FIG. 28A

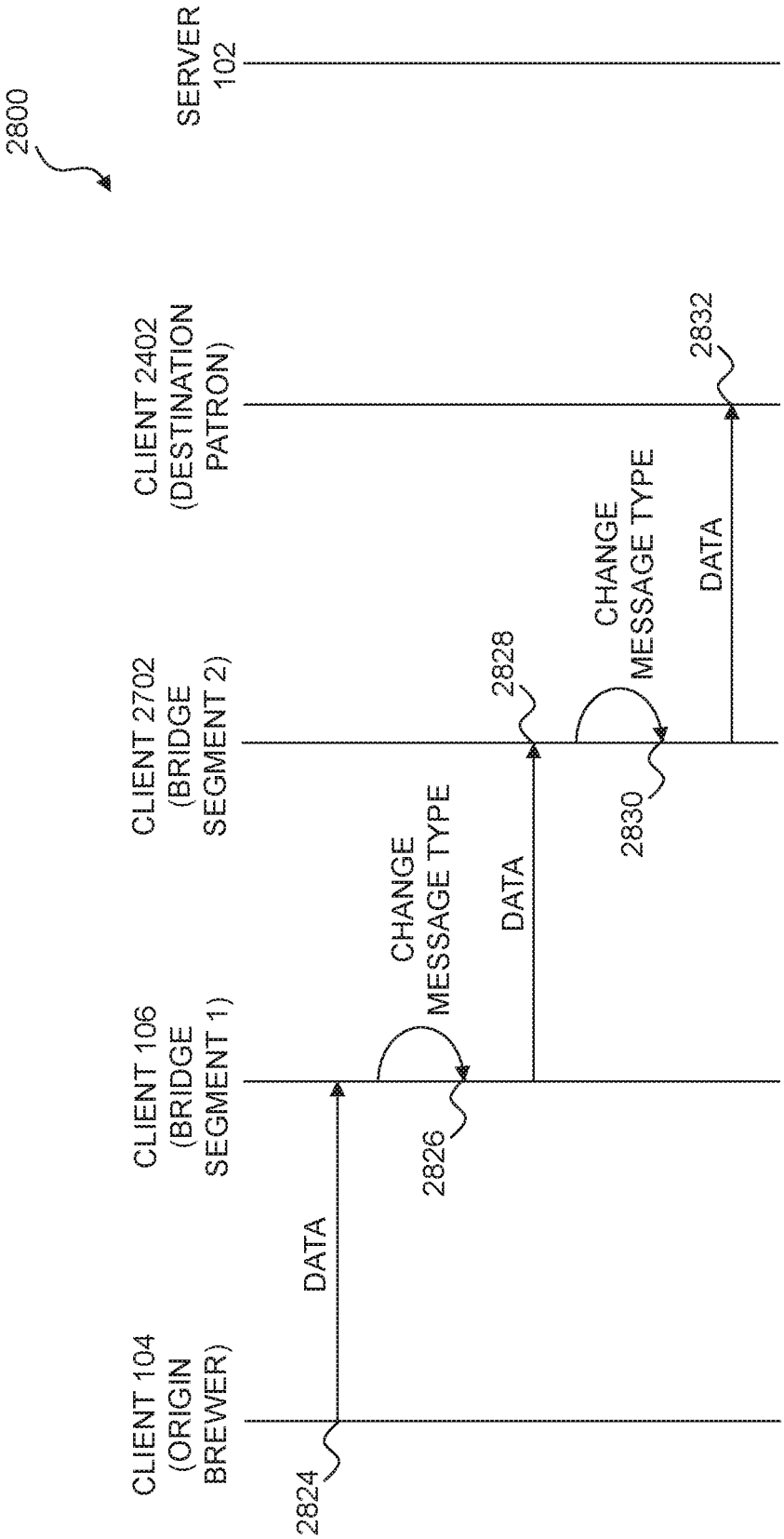

2800
SERVER 102
CLIENT 2402 (DESTINATION PATRON)
CLIENT 2702 (BRIDGE SEGMENT 2)
CLIENT 106 (BRIDGE SEGMENT 1)
CLIENT 104 (ORIGIN BREWER)
2824
DATA
2826
CHANGE MESSAGE TYPE
DATA
2828
2830
CHANGE MESSAGE TYPE
DATA
2832

FIG. 28B

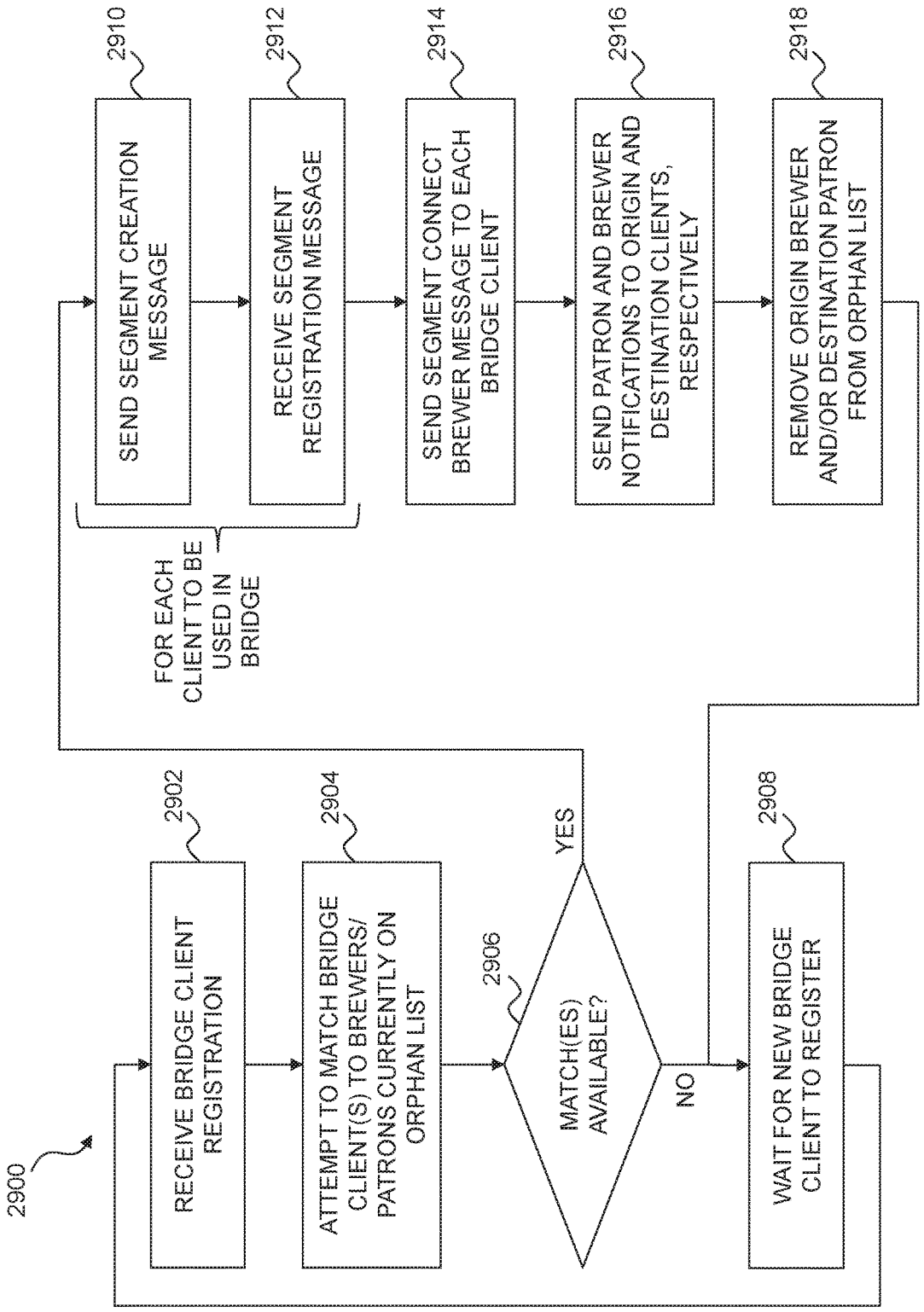

2900
RECEIVE BRIDGE CLIENT REGISTRATION
2902
ATTEMPT TO MATCH BRIDGE CLIENT(S) TO BREWERS/ PATRONS CURRENTLY ON ORPHAN LIST
2904
MATCH(ES) AVAILABLE?
2906
YES
NO
WAIT FOR NEW BRIDGE CLIENT TO REGISTER
2908
FOR EACH CLIENT TO BE USED IN BRIDGE
SEND SEGMENT CREATION MESSAGE
2910
RECEIVE SEGMENT REGISTRATION MESSAGE
2912
SEND SEGMENT CONNECT BREWER MESSAGE TO EACH BRIDGE CLIENT
2914
SEND PATRON AND BREWER NOTIFICATIONS TO ORIGIN AND DESTINATION CLIENTS, RESPECTIVELY
2916
REMOVE ORIGIN BREWER AND/OR DESTINATION PATRON FROM ORPHAN LIST
2918

FIG. 29

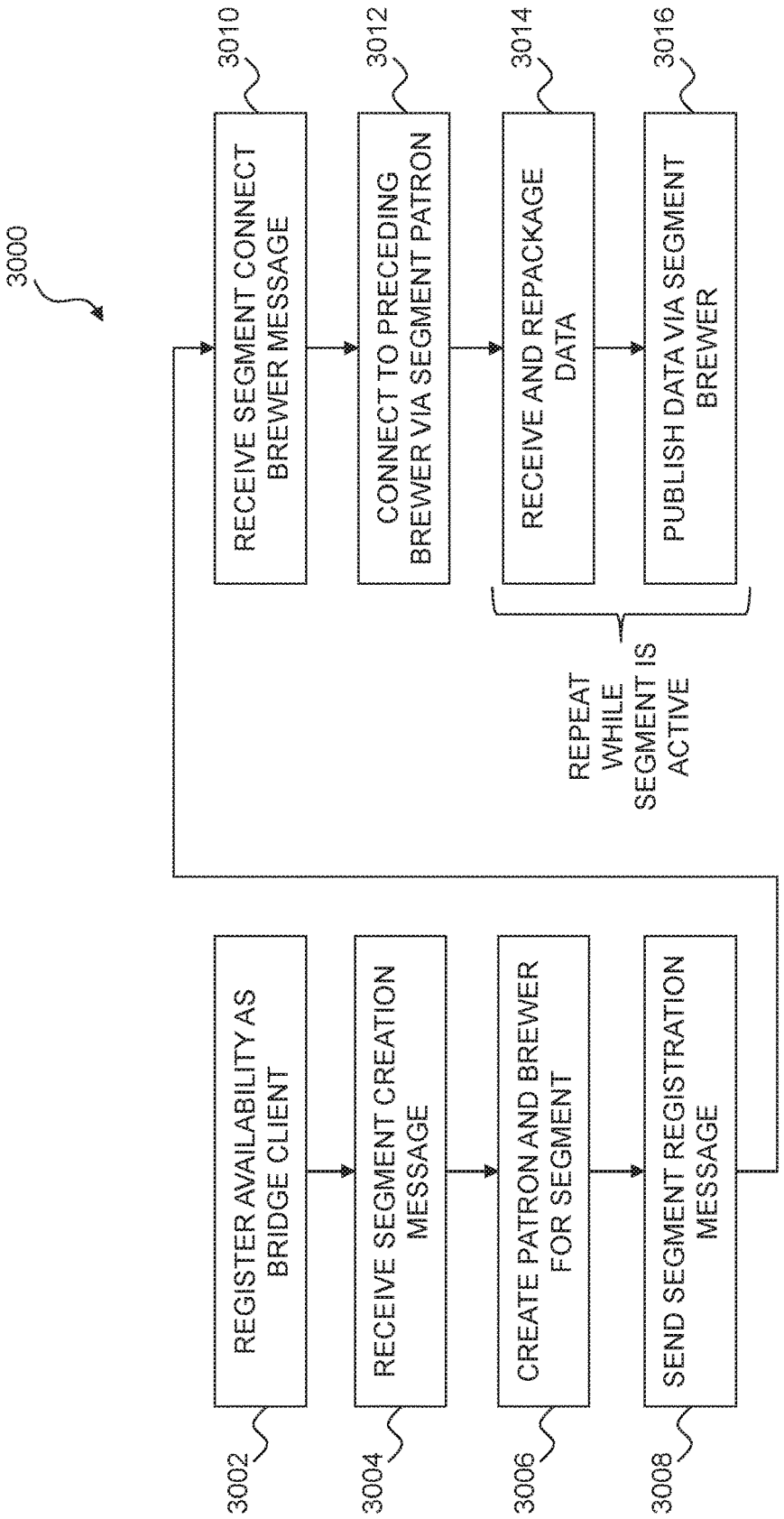

3000
REGISTER AVAILABILITY AS BRIDGE CLIENT
3002
RECEIVE SEGMENT CREATION MESSAGE
3004
CREATE PATRON AND BREWER FOR SEGMENT
3006
SEND SEGMENT REGISTRATION MESSAGE
3008
RECEIVE SEGMENT CONNECT BREWER MESSAGE
3010
CONNECT TO PRECEDING BREWER VIA SEGMENT PATRON
3012
RECEIVE AND REPACKAGE DATA
3014
PUBLISH DATA VIA SEGMENT BREWER
3016
REPEAT WHILE SEGMENT IS ACTIVE

FIG. 30

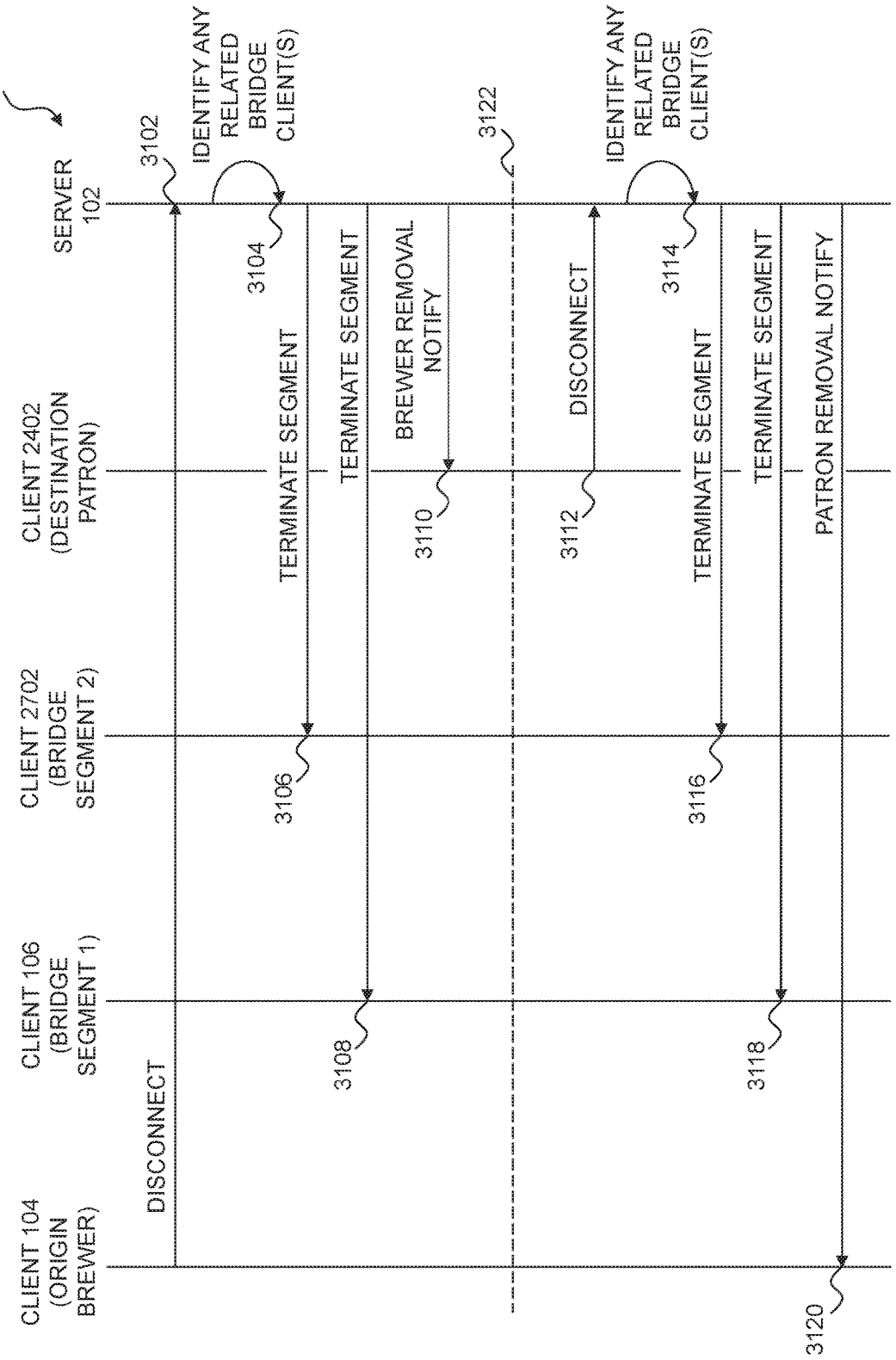

3100
SERVER 102
CLIENT 2402 (DESTINATION PATRON)
CLIENT 2702 (BRIDGE SEGMENT 2)
CLIENT 106 (BRIDGE SEGMENT 1)
CLIENT 104 (ORIGIN BREWER)
3102
IDENTIFY ANY RELATED BRIDGE CLIENT(S)
3104
TERMINATE SEGMENT
3106
TERMINATE SEGMENT
3108
BREWER REMOVAL NOTIFY
3110
3122
DISCONNECT
3112
IDENTIFY ANY RELATED BRIDGE CLIENT(S)
3114
TERMINATE SEGMENT
3116
TERMINATE SEGMENT
3118
PATRON REMOVAL NOTIFY
DISCONNECT
3120

FIG. 31A

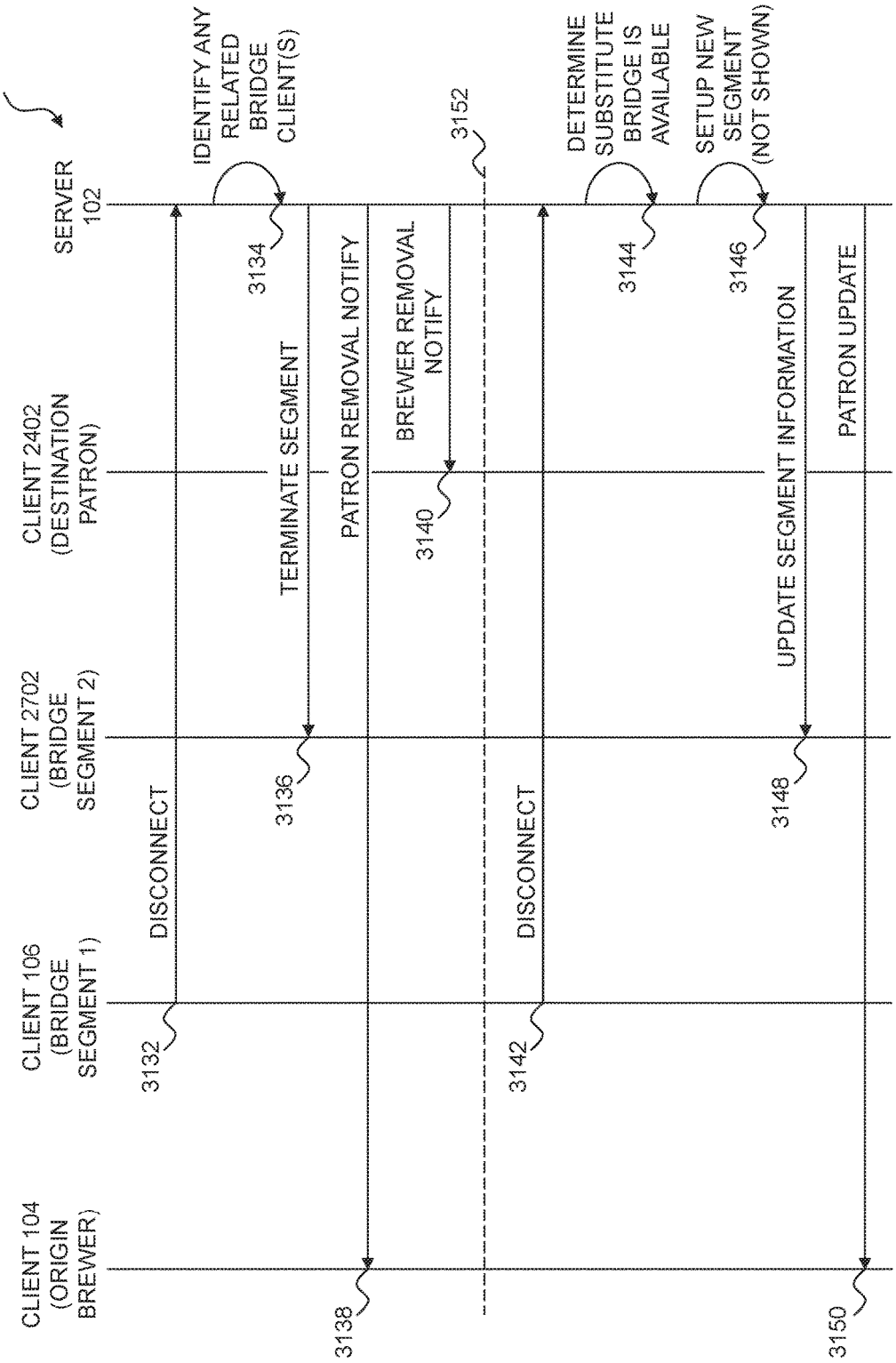

3130
SERVER 102
CLIENT 2402 (DESTINATION PATRON)
CLIENT 2702 (BRIDGE SEGMENT 2)
CLIENT 106 (BRIDGE SEGMENT 1)
CLIENT 104 (ORIGIN BREWER)
IDENTIFY ANY RELATED BRIDGE CLIENT(S)
3134
TERMINATE SEGMENT
3136
PATRON REMOVAL NOTIFY
3138
BREWER REMOVAL NOTIFY
3140
3152
DISCONNECT
3132
DISCONNECT
3142
DETERMINE SUBSTITUTE BRIDGE IS AVAILABLE
3144
SETUP NEW SEGMENT (NOT SHOWN)
3146
UPDATE SEGMENT INFORMATION
3148
PATRON UPDATE
3150

FIG. 31B

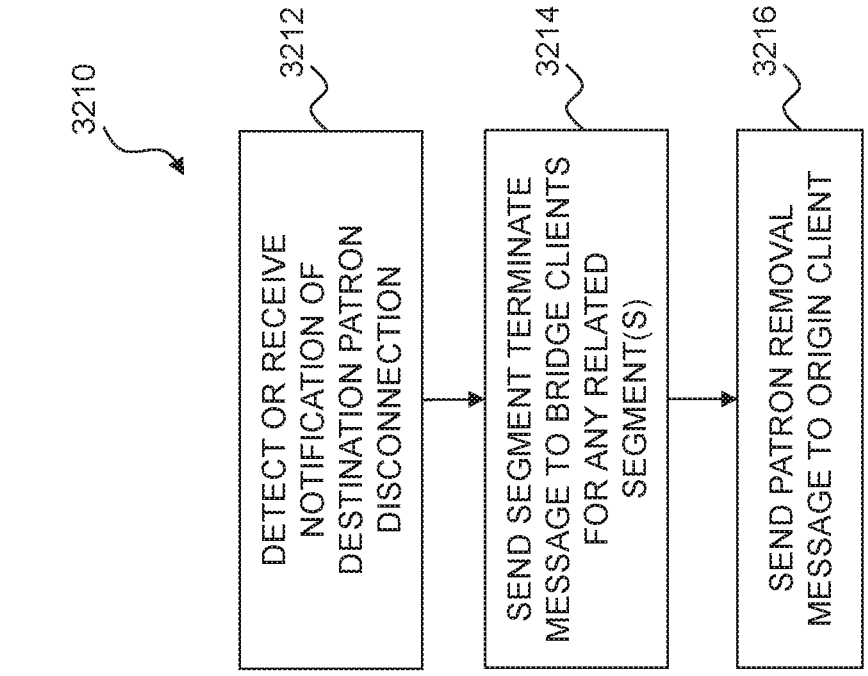


FIG. 32B

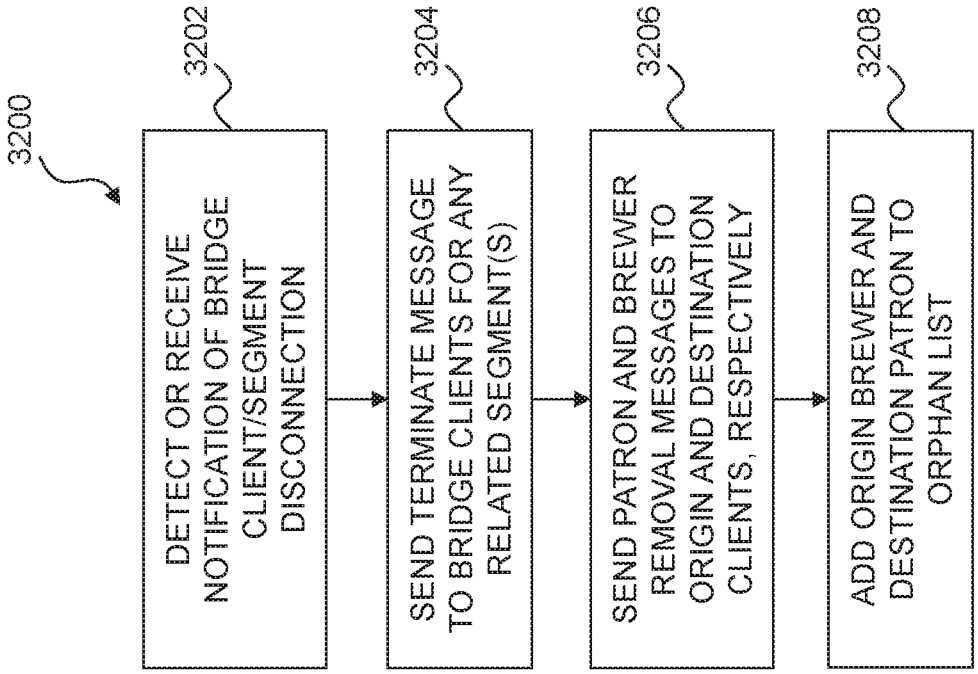


FIG. 32A

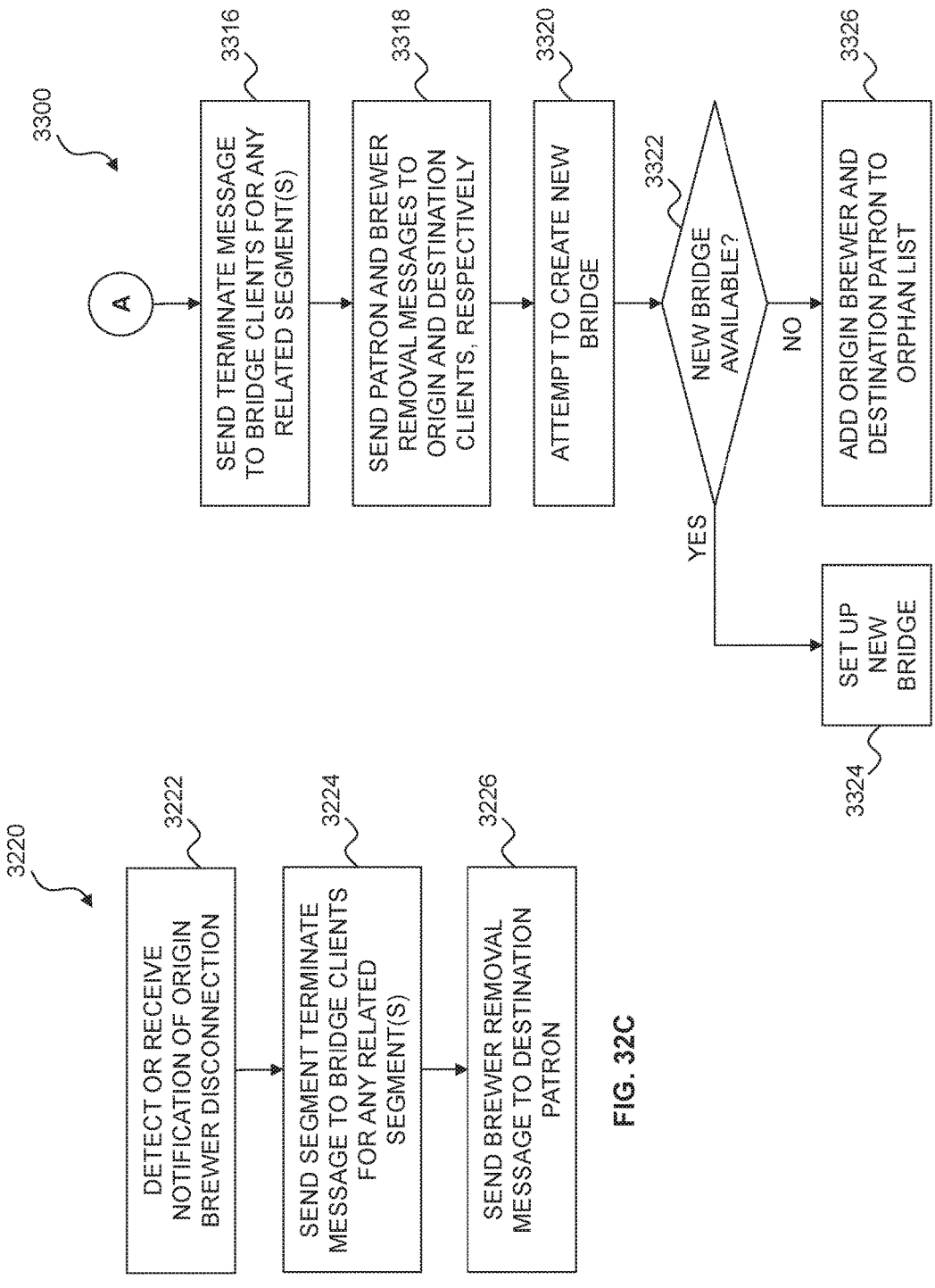


FIG. 33B

FIG. 32C

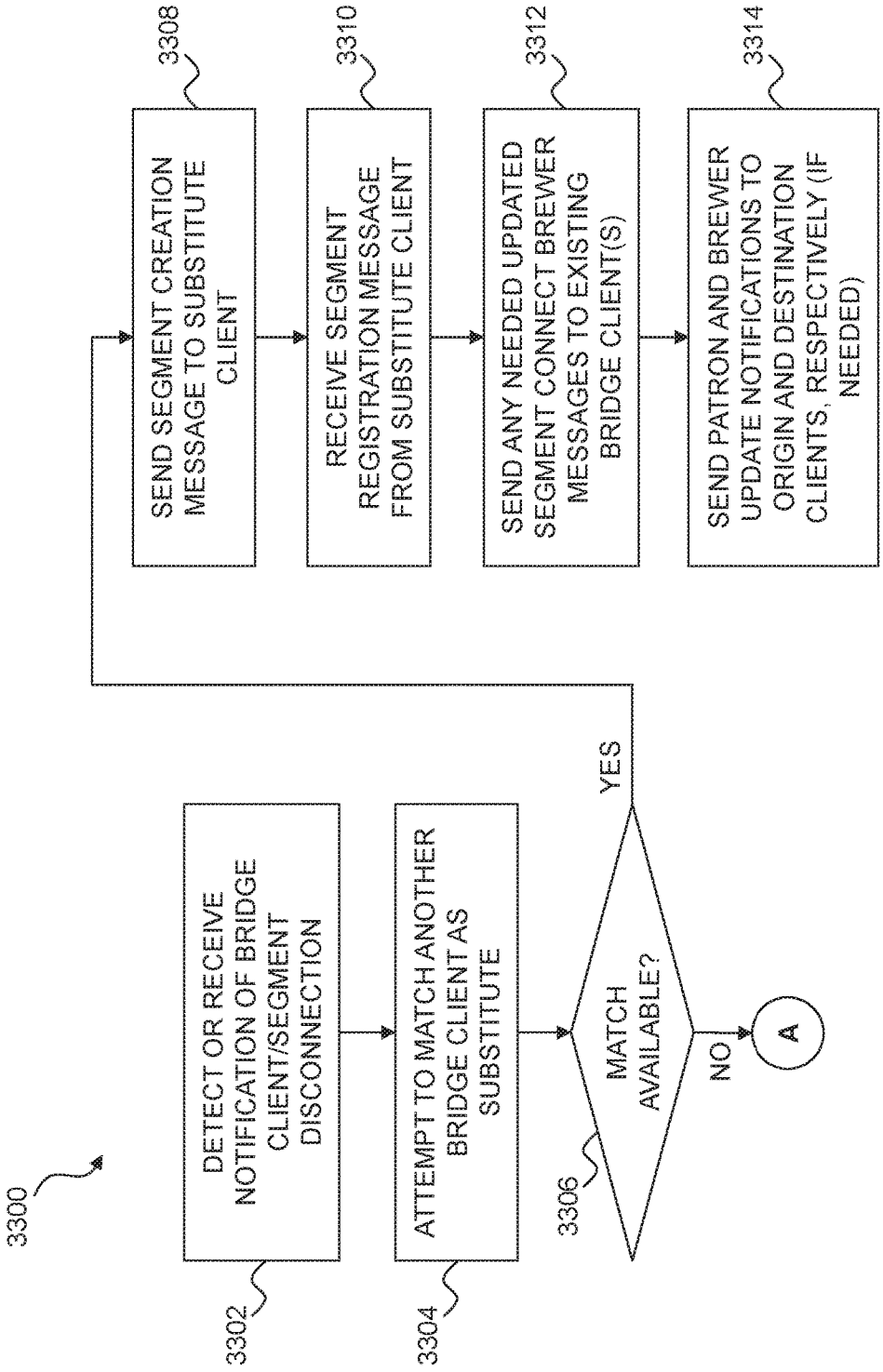

3300
DETECT OR RECEIVE NOTIFICATION OF BRIDGE CLIENT/SEGMENT DISCONNECTION
3302
ATTEMPT TO MATCH ANOTHER BRIDGE CLIENT AS SUBSTITUTE
3304
MATCH AVAILABLE?
3306
YES
NO
A
SEND SEGMENT CREATION MESSAGE TO SUBSTITUTE CLIENT
3308
RECEIVE SEGMENT REGISTRATION MESSAGE FROM SUBSTITUTE CLIENT
3310
SEND ANY NEEDED UPDATED SEGMENT CONNECT BREWER MESSAGES TO EXISTING BRIDGE CLIENT(S)
3312
SEND PATRON AND BREWER UPDATE NOTIFICATIONS TO ORIGIN AND DESTINATION CLIENTS, RESPECTIVELY (IF NEEDED)
3314

FIG. 33A

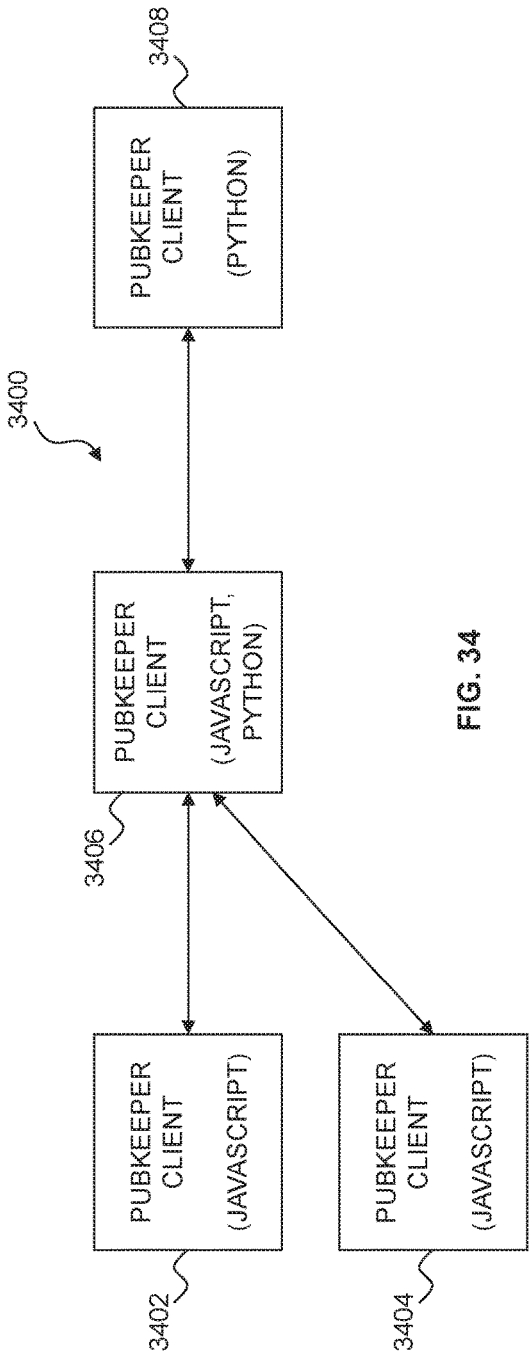

3400
PUBKEEPER CLIENT (PYTHON)
3408
PUBKEEPER CLIENT (JAVASCRIPT, PYTHON)
3406
PUBKEEPER CLIENT (JAVASCRIPT)
3402
PUBKEEPER CLIENT (JAVASCRIPT)
3404

FIG. 34

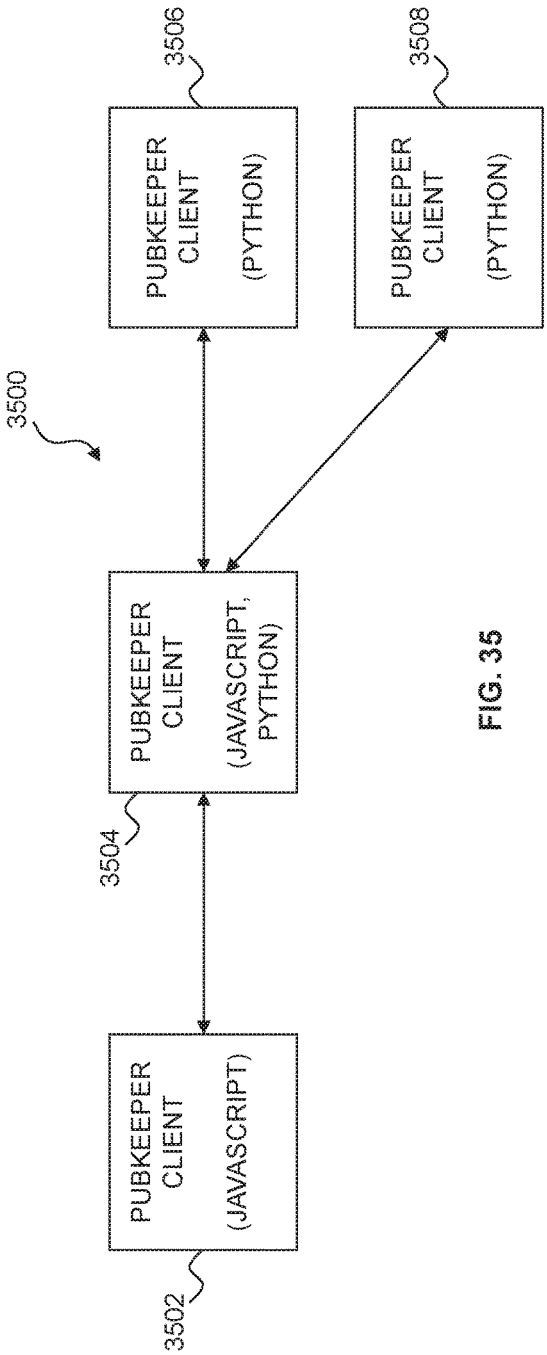

3500
PUBKEEPER CLIENT (PYTHON)
3506
PUBKEEPER CLIENT (PYTHON)
3508
PUBKEEPER CLIENT (JAVASCRIPT, PYTHON)
3504
PUBKEEPER CLIENT (JAVASCRIPT)
3502

FIG. 35

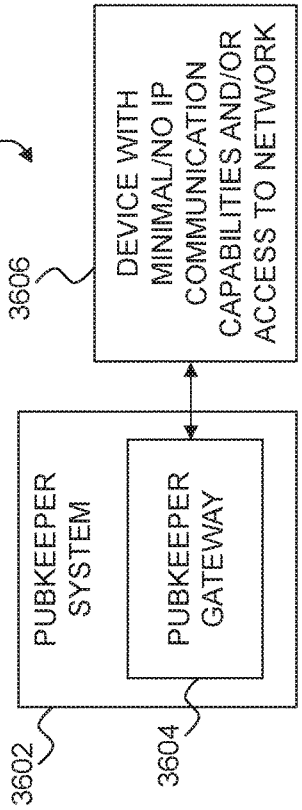

3600
3606
DEVICE WITH MINIMAL/NO IP COMMUNICATION CAPABILITIES AND/OR ACCESS TO NETWORK
PUBKEEPER SYSTEM
PUBKEEPER GATEWAY
3602
3604

FIG. 36

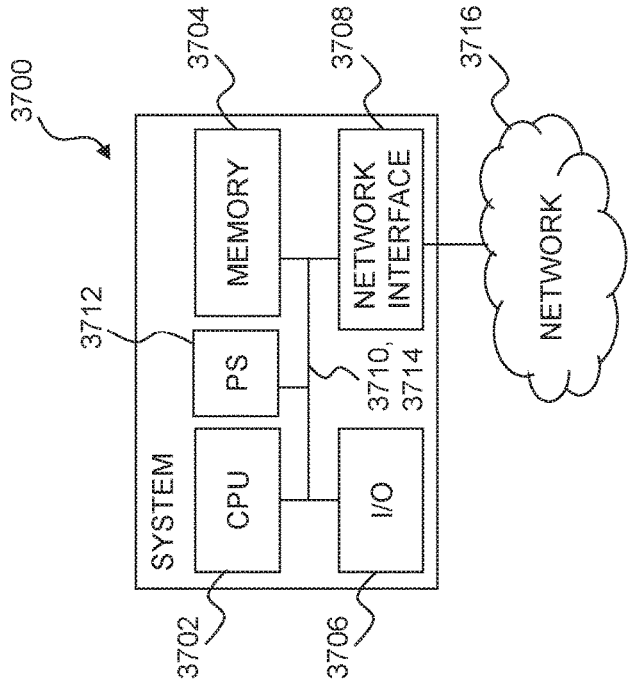

3700
3704
3708
3716
3712
SYSTEM
CPU
PS
MEMORY
I/O
3710, 3714
NETWORK INTERFACE
NETWORK
3702
3706

FIG. 37

SYSTEM AND METHOD FOR PROVIDING A COMMUNICATIONS LAYER TO ENABLE FULL PARTICIPATION IN A DISTRIBUTED COMPUTING ENVIRONMENT THAT USES MULTIPLE MESSAGE TYPES

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application 62/534,503, filed on Jul. 19, 2017, and entitled SYSTEM AND METHOD FOR PROVIDING A COMMUNICATIONS LAYER TO ENABLE FULL PARTICIPATION IN A DISTRIBUTED COMPUTING ENVIRONMENT THAT USES MULTIPLE MESSAGE TYPES, and U.S. Provisional Application 62/599,981, filed on Dec. 18, 2017, and entitled SYSTEM AND METHOD FOR PROVIDING BRIDGING FOR A COMMUNICATIONS LAYER TO ENABLE FULL PARTICIPATION IN A DISTRIBUTED COMPUTING ENVIRONMENT THAT USES MULTIPLE MESSAGE TYPES, both of which are hereby incorporated by reference in their entirety.

BACKGROUND

[0002] The proliferation of message types has caused difficulties in creating distributed systems in which all applications can fully participate. Accordingly, what is needed are systems and methods that address this issue.

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] For a more complete understanding, reference is now made to the following description taken in conjunction with the accompanying Drawings in which:

[0004] FIG. **1**A illustrates one embodiment of a messaging system;

[0005] FIG. **1**B illustrates one embodiment of a device within the system of FIG. **1**A on which a server and/or at least one client are running;

[0006] FIG. **2** illustrates one embodiment of a client that may be used in the system of FIG. **1**A;

[0007] FIG. **3**A illustrates one embodiment of a stack representing different layers of the client of FIG. **2** and how those layers may interact with an application;

[0008] FIG. **3**B illustrates another embodiment of the stack of FIG. **3**A;

[0009] FIG. **4**A illustrates one embodiment of how components within the client of FIG. **2** may interact;

[0010] FIG. **4**B illustrates one embodiment of different communication routes for an application;

[0011] FIG. **5** illustrates one embodiment of a sequence diagram showing steps by which a client may operate within the messaging system of FIG. **1**A;

[0012] FIG. **6** illustrates a more detailed embodiment of the messaging system of FIG. **1**A from a signal/control perspective;

[0013] FIG. **7** illustrates one embodiment of a sequence diagram showing a process by which a client may be started for use within the message system of FIG. **1**A;

[0014] FIG. **8** illustrates one embodiment of a flow chart representing a method for starting a client from an application's perspective;

[0015] FIG. **9** illustrates one embodiment of a flow chart representing a method for starting a client from the client's perspective;

[0016] FIG. **10** illustrates one embodiment of a sequence diagram showing a process by which clients may communicate with a server in order to communicate within the message system of FIG. **1**A;

[0017] FIG. **11** illustrates one embodiment of a sequence diagram showing a process by which a client may authenticate with a server within the message system of FIG. **1**A;

[0018] FIG. **12** illustrates one embodiment of the messaging system of FIG. **1**A with clients supporting different message types;

[0019] FIGS. **13**A and **13**B illustrate embodiments of a sequence diagram and a flow chart, respectively, showing a process by which a client may begin sending data to another client within the message system of FIG. **1**A;

[0020] FIGS. **14**A and **14**B illustrate embodiments of a sequence diagram and a flow chart, respectively, showing a process by which a client may begin receiving data from another client within the message system of FIG. **1**A;

[0021] FIG. **15** illustrates one embodiment of a sequence diagram showing a process by which a server may attempt to synchronize receiving clients before they begin to receive data from another client within the message system of FIG. **1**A;

[0022] FIG. **16** illustrates one embodiment of the messaging system of FIG. **6** from a data perspective;

[0023] FIG. **17** illustrates one embodiment of a sequence diagram showing a process by which a client may transfer data to another client within the message system of FIG. **1**A;

[0024] FIGS. **18**A-**18**D illustrate embodiments of flow charts representing methods for processing data by brews of FIG. **17**;

[0025] FIG. **19** illustrates one embodiment of a portion of the message system of FIG. **1**A with data for multiple topics being transferred from one client to another client;

[0026] FIG. **20** illustrates another embodiment of a portion of the message system of FIG. **1**A with data for multiple topics being transferred from one client to two clients;

[0027] FIG. **21** illustrates a more detailed embodiment of a portion of the message system of FIG. **1**A with data for multiple topics being transferred from one client to two clients using two different message types;

[0028] FIG. **22** illustrates one embodiment of a system within which an application uses a single client to communicate with multiple message systems;

[0029] FIG. **23** illustrates one embodiment of a system within which an application uses a separate client to communicate with each of multiple message systems;

[0030] FIG. **24** illustrates one embodiment of a system within which a bridge client converts and relays communications between two clients that cannot communicate directly;

[0031] FIGS. **25**A and **25**B illustrate a more detailed embodiment of the system of FIG. **24**;

[0032] FIG. **26** illustrates one embodiment of a sequence diagram showing a process by which a single bridge segment may be established within the system of FIGS. **25**A and **25**B;

[0033] FIG. **27** illustrates a more detailed embodiment of the system of FIG. **24** with multiple bridge segments;

[0034] FIGS. **28**A and **28**B illustrate one embodiment of a sequence diagram showing a process by which multiple bridge segments may be established within the system of FIG. **27**;

[0035] FIG. **29** illustrates one embodiment of a flow chart representing a method for establishing a bridge segment from a server's perspective;

[0036] FIG. **30** illustrates one embodiment of a flow chart representing a method for establishing a bridge segment from a bridge client's perspective;

[0037] FIGS. **31**A and **31**B illustrate one embodiment of a sequence diagram showing various processes by which disconnection may be handled for a bridge;

[0038] FIGS. **32**A thru **32**C and **33**A and **33**B illustrate embodiments of flow charts representing methods for dealing with disconnections in a bridge;

[0039] FIG. **34** illustrates one embodiment of a system in which multiple clients publish to a single bridge client;

[0040] FIG. **35** illustrates one embodiment of a system in which multiple clients receive data from a single bridge client;

[0041] FIG. **36** illustrates one embodiment of a system within which a gateway enables a device to fully participate in a message system when the device lacks the capability to do so itself; and

[0042] FIG. **37** illustrates one embodiment of a device that may be used to run a client and/or a server within the message system of FIG. **1**A.

DETAILED DESCRIPTION

[0043] The present disclosure is directed to a system and method for providing a communications layer to enable full participation in a distributed computing environment that uses multiple message types. It is understood that the following disclosure provides many different embodiments or examples. Specific examples of components and arrangements are described below to simplify the present disclosure. These are, of course, merely examples and are not intended to be limiting. In addition, the present disclosure may repeat reference numerals and/or letters in the various examples. This repetition is for the purpose of simplicity and clarity and does not in itself dictate a relationship between the various embodiments and/or configurations discussed.

[0044] Communication systems, such as distributed computer systems, use many different messaging types to communicate. For example, Socket.IO, WebSocket, and publisher/subscriber models such as ZeroMQ, as well as other transmission control protocol (TCP), user datagram protocol (UDP) based communications, and other link layer transports like Bluetooth, Xbee, etc., all enable bi-directional communications and are commonly used. However, while similarities exist, different messaging types frequently work in different ways that make them incompatible with each other.

[0045] For example, Socket.IO may be configured to use "rooms" to manage data, with data written to and read from the rooms. Web Socket uses full-duplex communication channels over a single TCP connection. ZeroMQ may be used in many different configurations, including a push/pull configuration and a publisher/subscriber configuration that uses a broker to manage publishers and subscribers. TCP uses a model in which the receiver is notified where to connect to the sender to receive data. UDP uses a model in which the sender is notified where to send the data to the receiver. Accordingly, different message types have different requirements for the sender and/or receiver, and those requirements must be met for the message type to be properly implemented under the defined standards for that message type.

[0046] To enable a single application to use multiple messaging types, a developer or user will generally need to separately configure the application to handle each message type, as well as clarify which type is to be used for a given communication. This approach lacks flexibility and typically makes adding and/or removing message types a non-trivial process. This approach may also make it difficult to port code to another application, which may need its own message type configurations to work properly.

[0047] As more and more devices are integrated into increasingly large networks, the use of non-compatible message types imposes an increasingly large cost. For example, based on their available message types, some devices and/or applications may be excluded from consideration entirely, others may be selected but may require additional effort to implement a particular message type into their firmware or software, and others may be selected simply because of their message compatibility even though some of their parameters (e.g., processing speed, memory, power consumption, security, and/or feature set) are less than ideal.

[0048] Another issue with typical messaging types is that thin clients, such as web browsers, cannot directly interact with the network as a full client. This limits the thin clients' functionality and requires that thin clients either be avoided entirely or operate with limited functionality with a reduced number of compatible messaging types (e.g., WebSocket or other hypertext transfer protocol (http) based communications but not ZeroMQ).

[0049] In addition, even if a thin client can communicate within a network using Web Sockets or another compatible messaging type, there is generally no standardized process by which communications can be compartmentalized. For example, a standard Web Socket connection may be used to connect to a server and broadcast information to all clients, but there may be no way to direct the information only to certain clients without implementing customized solutions. Broadcasting generally causes increased network usage and requires additional processing power as each client determines if a message is needed by that particular client.

[0050] Referring to FIG. **1**A, one embodiment of an environment **100** is illustrated in which a messaging system (which may be referred to herein as "Pubkeeper" or the "Pubkeeper system") may be used to address the previously described issues. The Pubkeeper system provides an abstraction layer between different messaging mechanisms and any applications or components that are sending and/or receiving messages. The abstraction layer enables Pubkeeper to manage multiple messaging types while using a common interface to provide access to those message types regardless of the requirements of each message type.

[0051] To accomplish this, the Pubkeeper system provides one or more servers **102** that provide management functionality and endpoint clients **104** and **106** that handle client side messaging. While the server **102** is used to register the clients **104** and **106** and obtain initial communication information from the clients to facilitate communications between the clients, data does not go through the server **102** unless required by the particular message type being used. Instead, the clients **104** and **106** are responsible for ensuring

that outgoing data is sent using the appropriate message type(s) and that incoming data is received and handled correctly.

[0052] As will be described in greater detail below, the manner in which data is sent between the clients **104** and **106** is based on the particular message type being used. For example, messages may be sent directly between clients (e.g., via ZeroMQ) or using an intermediary (e.g., a Socket. IO or Web Socket server) depending on the requirements of the particular message type being used. For purposes of this disclosure, a message type may represent a messaging system or library (e.g., ZeroMQ) and/or a particular protocol or standard (e.g., TCP, Bluetooth, or Xbee). In other words, a message type defines the mechanisms used to send and receive messages that are compatible with that message type.

[0053] Pubkeeper provides an abstraction layer that separates the user from the details of the message type. Using the Pubkeeper interface, an application developer or user can focus on their application's functionality and use common calls supported by Pubkeeper for sending and receiving messages, regardless of the underlying structure of a particular message type. Pubkeeper then manages the underlying communication layer to ensure that the messages are properly sent and/or received.

[0054] Pubkeeper clients can be written in different languages (e.g., Python, C++, Java, Go, or JavaScript) and/or for different operating systems and can communicate with each other as long as the selected message type is compatible. This is because the actual transfer mechanism between clients is fully compliant with the corresponding message type and is not altered by Pubkeeper. This means that Pubkeeper clients can be implemented for different operating systems and those clients will be compatible with any Pubkeeper system to which they all belong. This enables messaging functionality across operating systems without any additional effort by developers or users as long as a client can be run on each of the desired operating systems. Pubkeeper also provides full client functionality on platforms that would ordinarily not be able to participate as a full client (e.g., a web browser running a Pubkeeper JavaScript client can communicate either directly if the two Pubkeeper clients have a common message type or with other Pubkeeper clients via a bridge Pubkeeper client).

[0055] As illustrated in the environment **100** of FIG. **1**A, the Pubkeeper system may be distributed on multiple devices (e.g., the devices **108**, **110**, and **112**) that are coupled via a network **114**. Examples of such devices include cellular telephones (including smart phones), personal digital assistants (PDAs), netbooks, tablets, laptops, desktops, workstations, single board computers, single board microcontrollers, embedded systems, and any other computing device that can communicate with another computing device using a wireless and/or wireline communication link.

[0056] Such communications occur through one or more networks **114** and may be direct (e.g., via a peer-to-peer network, an ad hoc network, or using a direct connection), indirect, such as through a server, gateway, or other proxy (e.g., in a client-server model), or may use a combination of direct and indirect communications. The network **114** may be a single network or may represent multiple networks, including networks of different types. For example, the device **110** may be coupled to the device **112** via a network that includes a cellular link coupled to a data packet network, or via a data packet link such as a wide local area network (WLAN) coupled to a data packet network. Accordingly, many different network types and configurations may be used to couple the devices **108**, **110**, and **112**. It is understood that the devices **108**, **110**, and **112** themselves provide physical channels, but the server **102** and clients **104** and **106** that form the Pubkeeper system are shown with connections to each other to emphasize the communications within the Pubkeeper system.

[0057] With additional reference to FIG. **1**B, it is understood that a single device (e.g., the device **110**) may include the server **102** and one or more clients **104**, **106**, . . . , N. Furthermore, the server **102** may shift between devices based on availability, device parameters, network conditions, and/or other factors. For example, the first device in a Pubkeeper system may start the server **102**, and the server may automatically be moved to another device later. In another embodiment, the server **102** may be assigned to a dedicated device.

[0058] Although a dedicated device may be used to host only the server **102**, the server **102** may share a device with a client **104** in a Pubkeeper system. By avoiding the use of a dedicated device for the server **102**, the Pubkeeper system may be more flexible as any capable device can host the server **102** (e.g., a device that has enough processing power, memory, and network bandwidth). Furthermore, by using the ability of the Pubkeeper system to switch which device is hosting the server **102**, the Pubkeeper system is more resilient and may continue to operate despite device failures, localized network failures that affect only certain devices, and similar problems.

[0059] Accordingly, the Pubkeeper system provides a distributed messaging interface that enables applications to communicate using many different message types. By providing an application program interface (API) that exposes only needed functionality, Pubkeeper simplifies messaging and enables applications to focus on their own functionality while being integrated into the larger, multi-protocol messaging system that Pubkeeper enables.

[0060] Referring to FIG. **2**, one embodiment of the client **104** of FIG. **1**A is illustrated. The client **104** includes or is associated with one or more brews **202**, one or more modules **204**, and at least one brewer **206** or patron **208**. In order to communicate within the Pubkeeper system, the client **100** needs at least one brew **202**, at least one module **204** that corresponds to the brew **202**, and at least one brewer **206** or patron **208**. It is understood that some or all of the functionality provided by the various components may be combined (e.g., the brew **202** and the module **204** may be combined) or further separated into additional components.

[0061] Each Pubkeeper client is a generic manager that is able to operate within the Pubkeeper system (e.g., can communicate with the server **102**) and provides a registration framework for its brews **202**, brewers **206**, and patrons **208**.

[0062] A brew **202** is a wrapper for a particular module **204** and provides an interface between the module and brewers **206** and patrons **208**. A module **204** is a particular implementation of a message type and may come in different forms. For example, ZeroMQ may be a module, as may a library that enables Web Socket communications. A module **204** may include various layers of a network stack (e.g., an HTTP layer, a TCP layer, and an IP layer), or may use the network stack provided by the operating system of the

device on which the client **104** is running. Accordingly, a module **204** represents the actual send/receive mechanism for a particular message type and the corresponding brew **202** is a wrapper that provides a standardized interface (e.g., an API) for that module.

[0063] More specifically, a brew **202** provides a standardized interface for brewers **206** and patrons **208** that can be used to send and receive messages, respectively, with a module **204** regardless of the module's message type. For example, a standard call to a brew **202** from a brewer **206** may be used to send data and that brew **202** will be configured to accept the standard call and manage interactions with the module **204** in any way needed to accomplish the actual transmission of the data by the module **204**. The brewers **206** and patrons **208** need not be concerned with the module's actual mechanics of sending or receiving messages, respectively, and only need to know the standardized set of interactions that are made available by all brews **202**.

[0064] A brew **202** may also provide additional processing functionality, such as encryption/decryption. Although other components may be customized (e.g., brewers **206** may be configured to handle encryption and patrons **208** may be configured to handle decryption), the brew **202** will generally be the client component that handles customized processing. This ensures that the brewers **206**, patrons **208**, and modules **204** remain standardized.

[0065] A brewer **206** exposes an API for use by applications in sending messages for a particular topic and a patron **208** exposes an API for receiving information by an application for a particular topic. In other words, a brewer **206** provides an interface between the brews **202** and data sources. A patron **208** provides an interface between the brews **202** and data destinations, although a brew **202** may communicate directly with a data destination in some embodiments (e.g., FIG. **3**A). Accordingly, each brew **202** corresponds to a single module **204** and provides a standardized communications interface that is the same across all brews **202**. This enables all brewers **206** and patrons **208** to interact with a brew **202** in the same manner regardless of the underlying module **204** that is managed by the brew.

[0066] As described, there is typically a one-to-one correspondence between modules **204** and brews **202**, with each brew **202** corresponding to a single module **204**. However, there may be a one-to-many correspondence between brews **202** and/or brewers **206**/patrons **208**, with each brew interacting with multiple brewers and/or patrons. By separating the APIs that brewers **206** and patrons **208** provide to applications from the API that the brews **202** provide to the brewers **206** and patrons **208**, the brews **202** can be modified as needed (e.g., to address compatibility issues if the underlying module **204** is altered or to add additional processing functionality) without needing to change the brewers **206** and patrons **208**.

[0067] System functionality **210** enables the client **104** to operate as part of a Pubkeeper system. For example, the system functionality **210** enables the client **104** to interact with the server **102** for authentication and registration purposes, both of which will be described below in greater detail. From one perspective, the system functionality **210** is the client **104**, and the brews **202**, modules **204**, brewers **206**, and patrons **208** are components of the client that interact with the system functionality as needed.

[0068] In some embodiments, the client **104** may be executed as a thread of an application that is using the client **104**. The thread may run the system functionality **210** and the brews **202**, modules **204**, brewers **206**, and patrons **208** may be run as other threads. In other embodiments, the client **104** may be a process running the system functionality **210**, and the brews **202**, modules **204**, brewers **206**, and patrons **208** may be run as threads of that process. In still other embodiments, some or all of the brews **202**, modules **204**, brewers **206**, and patrons **208** may be run as their own processes.

[0069] With additional reference to FIG. **3**A, one embodiment of a stack **300** illustrates the relationships between a brew **202**, a module **204**, brewer(s) **206**, and patron(s) **208** as layers through which data passes to and from an application **302**. It is understood that the "IN" and "OUT" are from the Pubkeeper client's perspective in FIG. **3**A, and would be reversed from the perspective of the application **302**.

[0070] The arrow labeled "DATA TRANSFER" is data that is being sent or received by the client on behalf of the application **302**. The arrow labeled "DATA IN" represents data that has been received by the client **104** from the application **302** and is to be sent by the client.

[0071] Data that has been received by the client **104** from a data source (e.g., another application) can be sent to the application **302** using either a pull process or a push process. In the present example, the pull process moves the data from the brew **202** through the patron **208** to the application **302**. This enables the patron **208** to provide queuing functionality for the brew **202**. In other words, the brew **202** can push data to the patron **208**, which can then queue the data until the application **302** is ready to pull it. This is represented by PULL part of the arrow labeled "DATA OUT (PULL/PUSH)." Because the application **302** can pull the data whenever there is data available and the application **302** is ready, thread safety is not generally an issue. In other embodiments, the patron **208** may be used by the brew **202** to decrypt the data before pushing it to the application **302**. This is represented by PUSH part of the arrow labeled "DATA OUT (PULL/PUSH)."

[0072] Another push process bypasses the patron **208** and moves the data directly from the brew **202** to the application **302**. For example, if the brew **202** is handling decryption, there may be no need to push the data through the patron **208**. This is represented by the arrow labeled "DATA OUT (PUSH)." Because data structures may be shared between threads and the application **302** may receive pushed data at any time, thread safety is generally needed when data is pushed to the application **302**.

[0073] Whether data is pushed directly from the brew **202** or through the patron **208** may depend on whether encryption is enabled. If encryption is not enabled, the brew **202** may push the data directly to the application **302** (although pushing through the patron **208** would still be possible). If encryption is enabled, whether data is pushed directly from the brew **202** or through the patron **208** may depend on which component is responsible for decryption. If the brew **202** is responsible for decryption, the brew **202** may push the data directly to the application **302** (although pushing through the patron **208** would still be possible). If the patron **208** is responsible for decryption, the brew **202** would need the patron **208** to decrypt the data being pushed. In such cases, the brew **202** may call the patron **208** for decryption and then send the data out itself or may simply push the data through the patron **208** following decryption.

[0074] It is understood that other embodiments may be configured for different data flows. For example, in one embodiment, the brew **202** may have queuing capabilities and the application **302** may be able to pull directly from the brew **202**. In another embodiment, the patron **202** may have push capabilities and brew **202** may push to the patron **208**, which may in turn push the data to the application **302**. Accordingly, while many examples in the present disclosure use the patron **208** for pulling data and the brew **202** for pushing data, other configurations are also possible.

[0075] As illustrated, the actual send/receive mechanisms of the module **204** and brew **202** are shielded from the application **302**, which uses a standard set of calls with brewer(s) **206** and/or patron(s) **208** in order to send or receive (e.g., pull) data. In turn, the brew **202** shields the brewer(s) **206** and patron(s) **208** from the module **204**. The brewer(s) **206** and/or patron(s) **208** use a standard set of calls with the brew **202** to send or receive data via the module **204**. Because data is only pushed to the application **302** by the brew **202** (and not pulled from the brew **202**), there are no calls by the application **302** to the brew **202** as required for pulling data from the patron **208**.

[0076] In the present example, there is a one-to-one correspondence between brews **202** and modules **204** within a client. Without a module **204**, a brew **202** cannot send information, as the module handles the actual transmission/reception for that message type. Without a brew **202**, the brewers **206** and patrons **208** will not be able to use the module **204** because the brewers **206** and patrons **208** rely on standardized calls to the brew **202**. Accordingly, each brew **202** is designed specifically for a particular module **204**. Without the brews **202**, each brewer **206** and patron **208** would need to know how to use the module **204**, which would complicate the construction and maintenance of brewers and patrons. In a client with multiple brews **202**, the brewers **206** and patrons **208** would be even more complex.

[0077] The Pubkeeper system is designed to allow new brews **202** and modules **204** to be added without needing corresponding changes to Pubkeeper clients, brewers **206**, patrons **208**, and system functionality **210**. It is understood that, in some embodiments, it may be desirable to make changes to the clients **104**/**106**, brewers **206**, and/or patrons **208** for one or more brews **202**. However, such changes may reduce the flexibility of the Pubkeeper system and/or reduce Pubkeeper's uniformity across large and/or multiple deployments.

[0078] With additional reference to FIG. **3**B, one embodiment of the stack **300** with an additional brew **202***b* and module **204***b* illustrates various similarities and differences between components. Each module **204***a* and **204***b* is different due to the different message types being implemented. Similarly, each brew **202***a* and **202***b* is different because each brew must interact with its corresponding module. However, both brews **202***a* and **202***b* expose an identical API that is used to interact with brewers and patrons.

[0079] All brewers **206***a*-**206***c* have identical send functionality ("send" being from the application's perspective), but are topic specific. More specifically, the Pubkeeper system uses "topics" to track what data goes where. Topic specific data may be routed into corresponding publication/subscription channels, sent directly to particular destinations (e.g., rooms), or handled in many different ways depending on the particular message type used to send the data. All brewers **206***a*-**206***c* expose an identical API that is used to interact with the application **302**.

[0080] All patrons **208***a* and **208***b* have identical receive functionality ("receive" being from the application's perspective), but are topic specific. Both patrons **208***a* and **208***b* expose an identical API that is used to interact with the application **302**. As shown, there may be different numbers of brewers **206** and patrons **208** within a client. It is understood that describing various components in this example as identical means that they have substantially similar functionality, as customized components may be integrated into the stack **300** if desired.

[0081] Referring to FIG. **4**A, one embodiment of a brew **202** is illustrated with brewers **206***a* and **206***b*, and patrons **208***a* and **208***b*. The abstraction layers provided by brews **202** and brewers **206**/patrons **208** enable the brew **202** to interact with its corresponding module (not shown) while brewers **206** and patrons **208** represent topics.

[0082] In the present example, the brewer **206***a* represents Topic **1** and the brewer **206***b* represents Topic **2**. The patron **208***a* represents Topic **1** and the patron **208***b* represents Topic **3**. Both brewers **206***a* and **206***b* and both patrons **208***a* and **208***b* are communicating using the same message type represented by the brew **202**. However, by partitioning data into defined topics, the Pubkeeper system can maintain a single abstraction layer for a particular message type using the brew **202** while providing a more granular level of control over what data is being sent/received with respect to various destinations/sources using the brewer **206**/patron **208** layer. This enables applications to restrict their sending/receiving to specific topics and/or specific destinations/sources while maintaining a common interface for actually sending and receiving the data for those topics or destinations/sources.

[0083] In the present example, a brewer **206** is limited to one topic and a patron **208** may be limited to one topic or may enable the use of wildcards to subscribe to more than one topic. However, it is understood that, in some embodiments, a brewer **206** and/or patron **208** may be configured to handle multiple topics.

[0084] As illustrated in FIG. **4**A with respect to the brewer **206***a* and patron **208***a*, data may loop back to the same client based on topic. More specifically, the brewer **206***a* is sending data out for Topic **1** and the patron **208***a* is receiving data for Topic **1**, which means that the patron **208***a* will receive the data being sent by the brewer **206***a*. Accordingly, internal communications (e.g., within an application) may be integrated into the same Pubkeeper system that is used for external communications as long as the internal communications are routed through the client **104**. This ability to route internal application messages through the Pubkeeper system enables distributed systems to be built that do not differentiate between internal and external messaging, making it as easy to communicate with an external application (either on the same device or a different device) as within an application itself.

[0085] With additional reference to FIG. **4**B, due to the flexibility provided by a Pubkeeper system **402** with respect to whether particular communications for an application **302** are routed through the Pubkeeper system **402**, the application **302** may be easily configured to handle communications in many different ways. More specifically, Pubkeeper does not require an "all or nothing" approach with an application and allows selected communications to be routed through a

Pubkeeper system. For example, while a web browser (e.g., the application **302**) may use a JavaScript Pubkeeper client **104** to communicate with another Pubkeeper client (not shown) using Websockets (represented by line **404**), the web browser **302** may also use other connections (e.g., Websocket or WebRTC) (represented by line **406**) that do not pass through the client **104**. Such other connections **406** would not be part of the Pubkeeper system **402** to which the client **104** belongs even though the Websocket communications **404** are part of the Pubkeeper system. However, the web browser **302** may choose to only use support provided by the client **104**, in which case all connections from the web browser **302** would be fully integrated into the Pubkeeper system **402**.

[0086] Referring to FIG. **5**, a method **500** illustrates one embodiment of a process that may be performed within a Pubkeeper system for a Pubkeeper client (e.g., the client **104** of FIG. **1**) to join and operate within the Pubkeeper system. More detailed examples of each step will be provided in following embodiments.

[0087] In step **502**, an application (e.g., the application **302** of FIG. **3**A) starts the client **104**, which includes creating and configuring various options (e.g., the address and port information of the Pubkeeper server(s)) and components (e.g., brewer(s) **208** and/or patron(s) **208**) of the client. In step **504**, the client registers with the server **102**.

[0088] In step **506**, the server **102** sends the client **104** a list of only the brewers **206** and/or patrons **208** relevant to the client **104**. For example, the server **102** may examine the client's registered brewers **206** and/or patrons **208** and return only the brewers **206** and/or patrons **208** that correspond to those registered by the client **104**. In other embodiments, the server **102** may send the client **104** a list of all brewers **206** and patrons **208** that are available within the Pubkeeper system managed by the server **102**.

[0089] In step **508**, the client **102** establishes connections with the brewers **206** and/or patrons **208** in which the client is interested. In step **510**, the client's brewers **206** and/or patrons **208** communicate with other brewers **206** and/or patrons **208** within the Pubkeeper system. Steps **506**, **508**, and **510** may repeat as the server **102** updates the client **104** whenever relevant brewers **206** and patrons **208** are added to and removed from the Pubkeeper system.

[0090] Referring to FIG. **6**, one embodiment of a Pubkeeper system **600** is illustrated from a signal/control perspective with third party applications **602** and **604**. A later embodiment (FIG. **16**) illustrates the Pubkeeper system **600** from a data perspective. It is understood that some signaling may be dependent on the particular message type (e.g., between the modules **204***a* and **204***b* as illustrated by line **606** in order to establish a Web Socket connection or another connection type) and may not exist in all embodiments. Accordingly, FIG. **6** is largely directed to control signal paths within the Pubkeeper system **600** and between the Pubkeeper system **600** and the applications **602** and **604**. Such control signals include instructions and/or messaging needed to start and maintain pubkeeper clients, client/server communications, and internal client communications.

[0091] The applications **602** and **604** are not part of the Pubkeeper system **600**, but it is understood that in some embodiments one or both of the clients **104** and **106** may be embedded in the applications **602** and **604**, respectively, or the applications may otherwise contain or include the clients. However, the applications **602** and **604** would generally use the same interfaces provided by their respective client, brewers, and patrons regardless of how the clients are implemented with respect to the applications. In some alternate embodiments, certain interfaces may be removed or replaced and an application may communicate with a client in different ways (e.g., if some or all of the functionality of the client is written into the application itself).

[0092] Although the clients **104** and **106** are shown as separate from their respective brews **202**, modules **204**, and brewers **206**/patrons **208**, the separation is merely to illustrate the interaction between the clients **104** and **106** and the components that are included within or are otherwise part of each client. Similarly, from the signaling perspective of FIG. **6**, the brews **202***a* and **202***b* are illustrated as wrappers for their respective modules **204***a* and **204***b*. From the data perspective that is discussed later with respect to FIG. **16**, the brews **202***a* and **202***b* are illustrated as separate from their respective modules in order to better illustrate the flow of data through each client and its components.

[0093] For purposes of example, the client **104** is a JavaScript client and the application **602** is a web browser. The Pubkeeper client **104** enables the web browser, which would ordinarily be limited in its messaging interactions, to interact fully with the Pubkeeper system and any supported message types. The client **106** is a Python client and the application **604** is any application that may be installed on or used with a device. The application **602** is sending data for "Topic **1**" to the application **604** via the Pubkeeper system **600**. Accordingly, the client **104** includes a brewer **206** for Topic **1** and the client **106** includes a patron **208** for Topic **1**. The selected message type (MT) is "MT 1," which can be any message type supported by both of the clients **104** and **106** (e.g., Web Sockets, WebRTC, or any other message type).

[0094] Examples of the creation and/or purpose of the illustrated signal paths of FIG. **6** will be described in various embodiments below.

[0095] With additional reference to FIG. **7**, a sequence diagram **700** illustrates one embodiment of a process by which the client **104** may be started and registered with the server **102** of FIG. **6**. The process of FIG. **7** provides a more detailed example of steps **502** and **504** of FIG. **5** and describes signal paths **608***a*, **610***a*, **612***a*, and **614***a* of FIG. **6**. While FIG. **7** is directed to the client **104**, the client **106** would perform an identical process using signal paths **608***b*, **610***b*, **612***b*, and **614***b* of FIG. **6**. It is understood that some steps may occur in a different order than that shown, depending on the particular startup sequence that takes place. For example, step **706** may occur later than shown.

[0096] In step **702**, the application **602** starts the client **104**. This may occur as part of the application's startup process if the client **104** is embedded or otherwise included within the application **602**, or may be a separate process that is initiated by the application **602** during or after the application's own startup process. The start command may be formatted in many different ways and may include different type of information. For example, the command may be similar to "client.name=PubkeeperClient(token, config={ configuration information}).

[0097] The token is an authentication token (if needed) for use with the server **102**. The configuration information may include such information as the IP/port information of the Pubkeeper server **102** (if not dynamically discovered or assigned), certificate information, connection timeout

parameters, and brewer/patron information (from which brew information may be extracted). In some embodiments, the configuration information may include brew information that is separate from brewer/patron information.

[0098] The brew information, which may be automatically discovered in some embodiments, may identify all brews **202** that are available to the client **104** and any needed information to use each brew. For example, a Web Socket brew **202** may be associated with IP/port information for a WebSocket server. In embodiments where the brews **202** are automatically discovered on startup, one or more locations where brews are stored may be provided to the client **104** or the client may simply scan default locations for available brews.

[0099] In step **704**, the application **602** creates and configures each brew (including the brew **202***a* of FIG. **6**) that is available to the client **104**. For example, the application may create a brew using a particular name and assign a module to the brew using websocket_brew=WebsocketBrew. In step **706**, the application **602** instructs the client **104** to start the brews **202**, which the client **104** does in step **708**. These steps determine which message types will be available to the client **104**. Because the brews **202** are wrappers for their respective modules **204**, the brew **202***a* starts the corresponding module **204***a* (for websockets in this example) in step **710**. At this point, the brew **202***a* does not have information about any brewers or patrons and may be considered "inactive," although it is ready to be used.

[0100] In steps **712** and **714**, the application **602** starts any needed brewers **206** and patrons **208**, respectively. For example, the application **602** may create the brewer **206** using brewer_name=Brewer('topic.name'). A unique brewer ID is assigned to the brewer **206** within the client **104**. With respect to FIG. **6**, only the brewer **206** would be started as no patrons are illustrated for the client **104** and step **714** would be omitted. Steps **712** and **714** also provide the application **602** with the information needed to send/receive data for specific topics. For example, by creating the brewer **206** with the desired topic, the application **602** will know to send data for that topic to the brewer **206**.

[0101] In step **716**, the application **602** registers the brews **202**, brewers **206**, and patrons **208** with the client **104**. For example, the application **602** may register the brew **202** with the client **104** using client.add_brew(websocket_brew) and may register the brewer **206** using client.add_brewer(brewer_name).

[0102] It is understood that registration may occur immediately after each brew **202**, brewer **206**, and/or patron **208** is created, rather than in the order illustrated in FIG. **7**. For example, the websocket_brew may be registered immediately following step **704**, rather than in step **712**, and the brewer **206** may be registered immediately following step **708**. It is understood that a brewer **206** or patron **208** is generally created after any brews **202** that are to be used. Otherwise the information for a later created brew **202** will need to be passed to the brewer **206** and/or patron **208**, which complicates the startup process.

[0103] In step **718**, the client **104** registers the brewers **206** and the patrons **208** with the server **102**. Step **718** may also be used to notify the server **102** of the client's brews **202** based on the registered brewers **206** and patrons **208**, although this information may be explicitly relayed to the server **102** in the same step or a separate step.

[0104] Although not shown, the client **106** would perform the same basic startup process as that of the client **104**, including the use of the websocket brew. However, rather than creating and registering the brewer **206**, the client **106** would create the patron **208** (e.g., "patron_name=Patron ('topic.name')" with the same topic as the brewer **206**) and then register the patron **208** (e.g., "client.add_patron(patron_name)"). A unique patron ID would be assigned to the patron **208** within the client **106**.

[0105] Although the application **602** is responsible for most of the initial startup processes in the present example, the client **104** may have more responsibility in other embodiments. For example, the application **602** may start the client **104** in step **702** and the client **104** may then initiate and perform steps **704**, **708**, **710**, **712**, and **714** without any additional instructions from the application **602**. In such embodiments, the client **104** may then report any needed information to the application **602**. Such information needed by the application **602** would include how to send data for Topic **1** to the brewer **206**.

[0106] Referring to FIG. **8**, a method **800** illustrates one embodiment of the process of FIG. **7** from the perspective of the application **602**. In step **802**, the application **602** starts the client **104**. In step **804**, the application **602** creates and configures any brews **202**. In step **806**, the application **602** instructs the client **104** to start the brews **202**. The method **800** then continues to step **808** where each brewer **206** and patron **208** to be used by the client **104** is created. In step **810**, each brewer **206** and patron **208** is registered with the client **104**. It is understood that the steps **808** and **810** may overlap and/or repeat, with brewers **206** and patrons **208** being created and registered until no more remain to be created or registered.

[0107] Referring to FIG. **9**, a method **900** illustrates one embodiment of the process of FIG. **7** from the perspective of the client **104**. In step **902**, the client **104** is started. In step **904**, the client **104** receives registration information from the application **602**. This registration information is used to track the brews, brewers, and/or patrons associated with the client. In step **906**, the brews, brewers, and/or patrons are registered with the server **102**.

[0108] It is understood that there are many different ways to order and track the clients and their brews, brewers, and patrons within the Pubkeeper system **600**. In the present example, the server **102** keeps track of all clients, brews, brewers, and patrons within the Pubkeeper system **600**, and each client keeps track of its own brews, brewers, patrons, and the clients, brewers, and patrons with which it is communicating. For example, a client may keep a record of all topics, the brewers and patrons for each topic, and the brews available for each brewer and patron as follows:

```
brewers {
    topic_1 {
        brewer_ID_123: [
            {
                name: websocket
                host: 127.0.0.1
                port: 9001
                encryption: encryption_key
            },
            {   name: zmq
                publish:
            }]
        client: resource to socket
```

-continued

```
        }
        topic_2 {
            brewer_ID_124: [
                {
                    name: websocket
                    host: 127.0.0.1
                    port: 9002
                    encryption: encryption_key
                },
                {   name: zmq
                    publish:
                }
        ]
            client: resource to socket
        }
}
patrons {
        topic_3 {
            patron_ID_128: [
                {
                    name: websocket
                    host: 127.0.0.1
                    port: 9011
                    encryption: encryption_key
                },
                {   name: zmq
                    publish:
                }]
            client: resource to socket
        }
```

[0109] In other embodiments, each client may receive a list of all brewers and patrons in the Pubkeeper system, even for currently inactive brewers and patrons.

[0110] Referring to FIG. **10**, a sequence diagram **1000** illustrates one embodiment of a process by which the client **104** may interact with the server **102** of FIG. **6**. For each of the clients **104** and **106** to operate within the Pubkeeper system **600** and communicate with each other, the server **102** should recognize them as clients and the clients should know which message type to use with each other. The process of FIG. **10** provides a more detailed example of steps **504**-**512** of FIG. **5** and describes signal paths **608***a* and **608***b* of FIG. FIG. **6**.

[0111] The clients **104** and **106** authenticate with the server **102** in steps **1002** and **1004**, respectively. In some embodiments, actual authentication may not occur and steps **1002** and **1004** may represent simple registration where each client **104** and **106** notifies the server **102** that the client is online. However, for security reasons, the present embodiment requires authentication to ensure that only authorized clients are able to operate within the Pubkeeper system **600**. It is understood that although the sequence diagram **1000** illustrates only a single brewer notification in step **1006** and a single patron notification in step **1008**, multiple brewers and/or patrons may be notified by each client **104** and **106** during these steps.

[0112] With additional reference to FIG. **11**, a sequence diagram **1100** illustrates one embodiment of a process by which the client **104** of FIG. **6** may authenticate with the server **102**. In step **1102**, the client **104** sends an authentication request to the server **102**. For example, the client **104** may be configured with an encryption token (e.g., a JavaScript Object Notation (JSON) Web Token (JWT)) issued or otherwise recognized by the server **102** and may present the token to the server **102**. In step **1104**, the server **102** determines whether the client **104** is to be authenticated (e.g., whether the client's JWT is valid for the Pubkeeper system **600**). Even if the token is valid, the token may be associated with particular privileges within the Pubkeeper system **600** and, if so, the server **102** would limit the actions of the client **102** to comply with those privileges.

[0113] In step **1106**, the server **102** responds to the client **104** and either grants or denies the authentication request. The response may also provide information on the client's privileges within the Pubkeeper system **600**. In step **1108**, if the request is granted, a secure channel may be established (if such a channel was not established during the authentication process) between the server **102** and the client **104**. The secure channel is used for notifications, heartbeats, and/or other messages between the server **102** and the client **104**.

[0114] Referring again to FIG. **10**, after authentication, the clients **104** and **106** register their brews, brewers, and/or patrons with the server **102** in steps **1006** and **1008**, respectively. It is understood that the registration may occur as part of the authentication process of steps **1002** and **1004**. For purposes of example, the client **104** registers the brewer **206** (FIG. **6**) and the client **106** registers the patron **208**.

[0115] At this point, because the client **104** has registered the brewer **206** for Topic **1** and the client **106** has registered the patron **208** for Topic **1**, the server **102** is able to identify that the two clients will need to communicate. Accordingly, in step **1010**, the server **102** determines which message type should be used between the two clients **104** and **106**. In the present example, the server **102** makes this decision because it is aware of all the brewers **206** and patrons **208** within the Pubkeeper system **600**, and can optimize the number of message types being used and therefore minimize the amount of the client resources needed for the connections.

[0116] At some point, the client **104** and/or the client **106** may completely disconnect or may at least terminate their corresponding brewer or patron. As shown in step **1018**, if the brewer is terminated, the client **104** may notify the server **102** of the brewer termination. In step **1020**, the server **102** may then send a brewer removal notification to the client **106**. As shown in step **1022**, if the patron is terminated, the client **106** may notify the server **102** of the patron termination. In step **1024**, the server **102** may then send a patron removal notification to the client **104**.

[0117] With additional reference to FIG. **12**, a simplified diagram of the Pubkeeper system **600** of FIG. **6** is illustrated with the client **104** capable of communicating with message types **1**, **2**, and **3**, and the client **106** capable of communicating with message types **1**, **2**, and **4**. Another client **1202** (not shown in FIG. **6**) is also present and is capable of communicating with message types **2**, **3**, and **4**.

[0118] Between the clients **104** and **106**, the server **102** could choose either MT **1** or MT **2** and the two clients could communicate normally. Such a selection could be based on many different criteria, including a default message type for the entire Pubkeeper system **600** or a preferred message type for a particular type of client (e.g., MT **1** for JavaScript clients when possible). The server **102** may also be configured to consider existing connections. For example, if the client **102** is already using MT **1** for communications with other clients (not shown), the server **102** may select MT **1** for use between the clients **104** and **106** so that the client **104** can continue using the same message type.

[0119] The server **102** may also be configured to consider possible future connections as shown in FIG. **12**. More specifically, the client **1202** can communicate with the client

104 using MT **2** or MT **3**, and can communicate with the client **106** using MT **2** or MT **4**. However, the only common message type for all three clients is MT **2**, so the server **102** may select that message type for the clients **104** and **106** even if the client **1202** does not currently have brewers or publishers corresponding to the client **104** or **106**. Accordingly, the server **102** may select a particular message type for use between the clients **104** and **106** based on many different criteria.

[0120] Returning again to FIG. **10**, after determining the message type to be used between the clients **104** and **106** in step **1010**, the server **102** notifies the clients of the available brewers **206** and patrons **208**, as well as the selected message type, in steps **1012** and **1014**, respectively. More specifically, continuing the example of steps **1006** and **1008**, the server **102** sends a message to the client **104** that informs the client **104** of the selected message type, the patron **208**, and any details needed to communicate with the patron **208** in step **1012**. The server **102** sends a message to the client **106** that informs the client **106** of the selected message type, the brewer **206**, and any details needed to communicate with the brewer **206** in step **1014**. The two clients **104** and **106** can then communicate using that message type as shown in step **1016**.

[0121] Referring to FIG. **13**A, a sequence diagram **1300** illustrates one embodiment of a process by which the client **104** of FIG. **6** may send or not send data. Prior to step **1302**, the client **104** has been started with the brewer **206**, but there is no registered patron **208** corresponding to the brewer **206** (e.g., the patron **208** of FIG. **6** has not yet been registered).

[0122] Accordingly, with respect to steps **1302** and **1304**, the brewer **206** (FIG. **6**) is able to send information, but there is no patron **208** registered to receive the information. Depending on the configuration of the application **602**, the application **602** may send data to the brewer **206** in step **1302**. However, as there is no patron **208** registered to receive the data, the brew **202***a* is not active for the brewer **206** and the brewer **206** will not send the data to the brew **202***a* as shown by incomplete line **1306**. In other embodiments, the brewer **206** may forward the data to the brew **202***a,* but the brew **202***a* would not send the data anywhere because there is no registered patron **208** for the brewer **206**.

[0123] In some embodiments, step **1306** may result in an error (e.g., to notify the client **104** and/or the application **602** that there is no destination and the data is not actually being sent) and/or the data may continue to be sent to the module **204***a* (and ignored by the module **204***a*) as the application **602** continues to provide data to send.

[0124] In step **1306**, a notification of a patron **208** is received by the client **104** from the server **102**. For example, another client (not shown) that includes the patron **208** may have been started. The notification may include any needed information for communication with the patron **208** (e.g., address and port information). The patron **208** corresponds to the topic of the brewer **206** and may be a patron at another client (e.g., the patron **208** of the client **106**) as shown or may be a patron within the client **104** itself.

[0125] In step **1308**, the client **104** identifies relevant brewers within the client, including the brewer **206**. In step **1310**, the client **104** notifies the brewer **206** of the patron **208** (as illustrated by line **616***a* of FIG. **6**), including any needed information for communication with the patron **208** (e.g., address and port information). In step **1312**, the brewer **206** activates the brew **202***a* (as illustrated by line **618***a* of FIG. **6**). This activation informs the brew **202***a* of the patron **208** and provides any corresponding patron information to the brew **202***a,* which makes the brew aware that it should start sending data received from the brewer **206** to the patron **208**.

[0126] It is understood that the brew **202***a* may already be active with respect to other brewers **206** and/or patrons **208**. Accordingly, the concept of "active" for a brew **202** in the present example applies on a per brewer/patron basis, and determines whether the brew **202** will send or receive data for a particular brewer/patron.

[0127] In step **1314**, the brewer **206** may encrypt the data being sent in embodiments where the brewer **206**, rather than the brew **202***a,* is responsible for data encryption. Accordingly, step **1314** may be omitted if not needed. It is understood that step **1314** may occur prior to activation of the brew **202***a* (e.g., prior to step **1312**).

[0128] In step **1316**, the brewer **206** begins sending data received from the application **602** (step **1302**) to the now active brew **202***a*. In step **1318**, the brew **202***a* performs any needed processing (e.g., formatting and/or encryption if the brew **202***a* is configured to encrypt the data) for the data to be sent. In step **1319**, the brew **202***a* sends the data received from the application **602** to the module **204***a* for transfer to the corresponding module of the other client. It is understood that when the clients **104** and **106** are started relatively simultaneously, step **1304** may be omitted and step **1306** would be the same as step **1014** of FIG. **10**, after which step **1302** would occur.

[0129] Referring to FIG. **13**B, a method **1320** illustrates one embodiment of the process of FIG. **13**A. In the present example, steps **1322**-**1328** are performed by the client **104** and step **1330** is performed by the brewer **206**. In step **1322**, the client **104** receives a new patron notification. In step **1324**, the client **104** looks up all of its registered brewers **206** that correspond to the patron's topic. In step **1326**, the client **104** pulls any needed brew information for the brew **202** that is to be used. In step **1328**, the client **104** notifies each brewer **206** that there is a new patron **208** and provides any needed information about the patron **208** and/or the brew **202** to each brewer **206**. In step **1330**, each brewer **206** instructs the brew **202** to start sending its data to the patron **208**.

[0130] Referring to FIG. **14**A, a sequence diagram **1400** illustrates one embodiment of a process by which the client **106** of FIG. **6** may receive and handle data. Prior to step **1402**, the client **106** has been started with the patron **208**, but either has not received the registration response of step **1012** (FIG. **10**) from the server **102** or there is no registered brewer (e.g., the brewer **206** of FIG. **6**) corresponding to the patron **208**. Accordingly, the patron **208** is not receiving any data.

[0131] In step **1402**, the client **106** receives a notification from the server **102** about the brewer **206**. The notification may include any needed information for communication with the brewer **206** (e.g., address and port information). In step **1404**, the client **106** identifies relevant patrons within the client, including the patron **208**. In step **1406**, the client **106** notifies the patron **208** of the brewer **206** (as illustrated by line **616***b* of FIG. **6**), including any needed information for communication with the brewer **206** (e.g., address and port information).

[0132] In step **1408**, the patron **208** activates the brew **202***b* (as illustrated by line **618***a* of FIG. **6**). This activation informs the brew **202***b* of the brewer **206** and provides any

corresponding brewer information to the brew **202***b*, which makes the brew aware that it should start receiving data from the brewer **206** for the patron **208**. At this point, the patron **208** may notify the brew **202***b* how the incoming data should be handled by defining a callback. For example, the patron **208** may instruct the brew **202***b* to send the data to the patron **208** (e.g., to be pulled by, or pushed to, the application **604**) or to send the data directly to the application **604** (e.g., push the data to the application **604**). As with the brew **202***a* of FIG. **13**A, the brew **202***a* may already be active with respect to other brewers **206** and/or patrons **208**. In step **1410**, the now active brew **202***b* receives the data from the module **204***b*. In step **1412**, the brew **202***b* performs any needed processing (e.g., formatting and/or decryption if the brew **202***b* is configured to decrypt the data) for the received data. In step **1414**, the brew **202***b* sends the data to the patron **208**. In step **1416**, the patron **208** may decrypt the data being received in embodiments where the patron **208**, rather than the brew **202***b*, is responsible for data decryption. Accordingly, step **1416** may be omitted if not needed. In step **1417**, the patron **208** sends the data to the application **604**.

[0133] In some embodiments, as illustrated below line **1419**, steps **1414**, **1416**, and **1417** may be replaced by a single step **1418**. In step **1418**, the brew **202***b* sends data directly to the application **604**. This avoids passing the data through the patron **208**.

[0134] Referring to FIG. **14**B, a method **1420** illustrates one embodiment of the process of FIG. **14**A. In the present example, steps **1422**-**1428** are performed by the client **106** and step **1430** is performed by the patron **208**. In step **1422**, the client **106** receives a new brewer notification. In step **1424**, the client **106** looks up all of its registered patrons **208** that correspond to the brewer's topic. In step **1426**, the client **106** pulls any needed brew information for the brew **202** that is to be used. In step **1428**, the client **106** notifies each patron **208** that there is a new brewer **206** and provides any needed information about the brewer **206** and/or the brew **202** to each patron **208**. In step **1430**, each patron **208** instructs the brew **202** to start patronizing (e.g., obtaining data from) the brewer **206**.

[0135] Referring to FIG. **15**, a sequence diagram **1500** illustrates one embodiment of a process by which multiple clients within the Pubkeeper system **600** of FIG. **6** may be synchronized. Such synchronization may be desirable in cases where multiple patrons are connecting to a new brewer. The synchronization process is an attempt to have the patrons start by receiving the same data from the brewer, rather than one patron missing data that is received by another patron. In the present example, the internal behavior of the clients **104**, **106**, and **1501** is not illustrated as previous diagrams (e.g., FIGS. **13**A and **14**A) have described embodiments of such behavior. Accordingly, client **104** includes brewer **206**, client **106** includes patron **208***a*, and client **1501** includes patron **208***b*.

[0136] As described in previous embodiments, each client **106** and **1501** registers its respective patron with the server **102** in steps **1502** and **1504**, and the client **104** registers its brewer **206** with the server in step **1506**. In step **1508**, the server **102** responds to the client **104** with brewer initialization information that notifies the client **104** of the patron **208***a* of the client **106** and the patron **208***b* of the client **1501**.

[0137] In steps **1510** and **1512**, the server **102** notifies the clients **106** and **1501** of the brewer **206**. In steps **1514** and **1516**, the clients **106** and **1501** acknowledge the notifications with patron synchronization messages that inform the server **102** that the respective patrons **208***a* and **208***b* are ready to receive data. In steps **1518** and **1520**, the server **102** notifies the client **104** of the patron synchronization messages.

[0138] As illustrated by a bracket identified by reference number **1522***a*, the server **102** may use a timeout period to ensure that any delays will be minimized. For example, the server **102** may wait a predefined period of time (e.g., 500 milliseconds) after sending the brewer notifications in steps **1510** and **1512**. If one or both of the patron synchronization messages are not received before the timeout period expires, the server **102** may send one or both of the messages in steps **1518** and **1520** (or a similar message that is not a synchronization message) following the timeout period. It is understood that this may be handled in many different ways. For example, a synchronization message may be sent only for a client from which a patron synchronization message was received.

[0139] In other embodiments, the client **104** may use a timeout period in addition to, or as an alternative to, a server based timeout. For example, as illustrated by a bracket identified by reference number **1522***b*, the client **104** may start a timeout period after receiving the brewer initialization information from the server **102** in step **1508**.

[0140] Regardless of the method in which the timeout period (if any) is implemented, the brewer **206** will being sending data to the patrons **208***a* and **208***b* in steps **1524** and **1526**. It is understood that the synchronization process may be omitted entirely in some embodiments, and that data will be sent to the patrons identified in step **1508** without any attempt at synchronization. If a particular patron is not available (e.g., a required connection cannot be established), the brewer **206** may not send data to that patron.

[0141] Referring to FIG. **16**, one embodiment of the Pubkeeper system **600** of FIG. **6** is illustrated from a data perspective. As shown, the server **102** and the clients **104** and **106** (e.g., the system functionality **210** of FIG. **2**) are not involved in the actual transfer of data from the application **602** to the application **604**.

[0142] With additional reference to FIG. **17**, a sequence diagram **1700** illustrates one embodiment of a process by which data flow may occur within the Pubkeeper system **600** of FIG. **17**. The data is to be sent from the application **602** to the application **604**.

[0143] In step **1702**, the data for Topic **1** is sent from the application **602** to the brewer **206** as the brewer **206** corresponds to Topic **1**. In step **1704**, the brewer **206** sends the data to the brew **202***a*, which identifies the brewer's ID as corresponding to Topic **1**. In step **1706**, the brew **202***a* performs any needed processing (e.g., formatting of the data for the module **204***a* and/or encryption). The brew **202***a* then sends the data to the module **204***a* in step **1708**.

[0144] In the present example, the brews **202***a* and **202***b* are responsible for encryption and decryption, respectively. In embodiments where the brewer **206** is responsible for encryption and the patron **208** is responsible for decryption, the sequence diagram **1700** may be modified as illustrated in FIGS. **13**A and **14**A to account for such encryption and decryption.

[0145] In step **1710**, the module **204***a* transfers the data to the module **204***b*. The transfer process may vary based on the particular transfer mechanism used by the message type represented by the modules **204***a* and **204***b*. The module

204*b* sends the received data to the brew **202***b* in step **1712**. In step **1714**, the brew **202***b* performs any needed processing (e.g., formatting of the data and/or decryption). The brew **202***a* then sends the data to the patron **208** in step **1716**. In step **1718**, the patron **208** queues the data (if needed) before sending the data to the application **604** in step **1720**. In some embodiments, the brews **202***a* and/or **202***b* may be capable of queueing. Steps **1716**-**1720** are represented in FIG. **16** by lines **1602***a* and **1602***b*, respectively, which show the data passing through the patron **208**.

[0146] In another embodiment, steps **1716**-**1720** may be replaced by a callback that bypasses the patron **208**. In this embodiment, the brew **202***b* may perform any needed queueing in step **1722** before sending the data directly to the application **604** in step **1724**. In other embodiments of the callback process, the brew **202***b* may not be capable of queueing and received data may be streamed directly to the application **604** or written to a storage area for later retrieval by the application **604**. Step **1724** is represented in FIG. **16** by line **1604**, which shows the data bypassing the patron **208**.

[0147] Referring to FIG. **18**A, a method **1800** illustrates one embodiment of a process of that may be executed by the brew **202***a* of FIG. **17** when the brew **202***a* is responsible for encryption. In step **1802**, unencrypted data is received from the brewer **206**. In step **1804**, the data is converted as needed for the module **1804**. This step prepares the data for sending by the module **204***a* and may vary based on the requirements of the module **204***a* (e.g., formatting and/or segmentation of the data). In step **1806**, the data may be encrypted if needed (e.g., if encryption is required or desired). In step **1808**, the data is sent to the module **204***a* for transmission.

[0148] Referring to FIG. **18**B, a method **1810** illustrates one embodiment of a process of that may be executed by the brew **202***b* of FIG. **17** when the brew **202***b* is responsible for decryption. In step **1812**, encrypted data is received from the module **204***b*. In step **1814**, the data is decrypted if needed. In step **1816**, the data is converted for the patron **208** if needed. In step **1816**, the data may be sent to the patron **208** or directly to the application **604**.

[0149] Referring to FIG. **18**C, a method **1820** illustrates one embodiment of a process of that may be executed by the brew **202***a* of FIG. **17** when the brew **202***a* is not responsible for encryption. In step **1822**, encrypted data is received from the brewer **206**. In step **1824**, the data is converted as needed for the module **1804**. This step prepares the data for sending by the module **204***a* and may vary based on the requirements of the module **204***a* (e.g., formatting and/or segmentation of the data). In step **1826**, the still encrypted data is sent to the module **204***a* for transmission.

[0150] Referring to FIG. **18**D, a method **1830** illustrates one embodiment of a process of that may be executed by the brew **202***b* of FIG. **17** when the brew **202***b* is not responsible for decryption. In step **1832**, encrypted data is received from the module **204***b*. In step **1834**, the data is converted for the patron **208** if needed. In step **1836**, the still encrypted data may be sent to the patron **208** for decryption and relay to the application **604**.

[0151] Referring to FIG. **19**, a diagram illustrates one embodiment of a system **1900**. The system **1900** includes a data source **1902** (Topics **1** and **2**), a data source **1904** (Topic **1**), a data destination **1906** (Topics **1** and **2**), and a data destination **1908** (Topic **2**). The data sources **1902** and **1904**, and the data destinations **1906** and **1908**, may be different parts of a single application or may be different applications.

[0152] The system **1900** further includes a client **104** and a client **106**. The client **104** is configured for message types **1**, **2**, and **3**, and includes a brewer **206***a* for Topic **1** and a brewer **206***b* for Topic **2**. The client **104** further includes a brew **202***a* and a corresponding module **204***a* (MT **1**), a brew **202***b* and a corresponding module **204***b* (MT **2**), and a brew **202***c* and a corresponding module **204***c* (MT **3**). The client **106** is configured for message types **1** and **2**, and includes a patron **208***a* for Topic **1** and a patron **208***b* for Topic **2**. The client **106** further includes a brew **202***d* and a corresponding module **204***d* (MT **1**) and a brew **202***e* and a corresponding module **204***e* (MT **2**).

[0153] As illustrated, the data source **1902** sends its Topic **1** data to the brewer **206***a* and its Topic **2** data to the brewer **206***b*. The data source **1904** sends its Topic **1** data to the brewer **206***a*. Each brewer **206***a* and **206***b* sends the data to all of the available brews **202***a*, **202***b*, and **202***c*, which can distinguish the data by brewer ID. By sending its data to all available brews **202***a*-**202***c*, a brewer **206** does not need to know which brew is being used for the actual transfer. In other embodiments, a brewer **206** may be configured with information as to which brew **202** will be used for transmission, and the brewer may send its data only to that brew.

[0154] A pubkeeper server **102** (not shown) has determined that the clients **104** and **106** should communicate using MT **1**. Accordingly, the data for both Topic **1** and Topic **2** is sent out by the brew **202***a* via the module **204***a*. Although the brews **202***b* and **202***c* receive the data, they are not active in this example and do not send the data to their corresponding modules **208***b* and **208***c*.

[0155] The module **204***d* receives the data for Topic **1** and Topic **2** and sends the data to the brew **202***d*. The module **204***e* and the brew **202***e* are inactive in this transaction. The brew **202***d* sends the Topic **1** data to the patron **208***a* and the Topic **2** data to the patron **208***b*. The patron **208***a* sends the Topic **1** data to the data destination **1906**. The patron **208***b* sends the Topic **2** data to the data destinations **1906** and **1908**.

[0156] Referring to FIG. **20**, a diagram illustrates one embodiment of a system **2000** that is a variation of the system **1900** of FIG. **19**. In the present example, the client **106** is associated with the data destination **1906** and a client **2002** is associated with the data destination **1908**. The client **104** communicates with the client **106** using MT **1** and the client **2002** using MT **2**. Unused modules and brews have been omitted from the clients **106** and **2002** for purposes of clarity.

[0157] As illustrated, the data source **1902** sends its Topic **1** data to the brewer **206***a* and its Topic **2** data to the brewer **206***b*. The data source **1904** sends its Topic **1** data to the brewer **206***a*. Each brewer **206***a* and **206***b* sends the data to all of the available brews **202***a*, **202***b*, and **202***c*. The brews **202***a* (MT **1**) and **202***b* (MT **2**) are the active brews. The data for both Topic **1** and Topic **2** is sent out by the brew **202***a* via the module **204***a* to the module **204***d*. The data for Topic **2** is sent out by the brew **202***b* via the module **204***b* to the module **204***e*. In the present example, the MT **1** and MT **2** modules are configured with different sockets or channels for different topics, and so only the data for Topic **2** (but not the data for Topic **1**) is sent to the module **204***e*.

[0158] The module **204***d* receives the data for Topic **1** and Topic **2** and sends the data to the brew **202***d*. The brew **202***d*

sends the Topic **1** data to the patron **208***a* and the Topic **2** data to the patron **208***b*. The patron **208***a* sends the Topic **1** data to the data destination **1906**. The patron **208***b* sends the Topic **2** data to the data destination **1906**.

[0159] The module **204***e* receives the data for Topic **2** and sends the data to the brew **202***e*. The brew **202***e* sends the Topic **2** data to the patron **208***c*. The patron **208***c* sends the Topic **2** data to the data destination **1908**.

[0160] Referring to FIG. **21**, a diagram illustrates one embodiment of a system **2100** (e.g., the system **2000** of FIG. **20**) in which a client **104** is to transfer data to clients **106** and **2108**. The client **104** includes a ZeroMQ brew **202***a* and a Web Socket brew **202***b*. It is understood that these are for purposes of example and may be any message type. The client **104** also includes a brewer **206***a* for Topic **1** and a brewer **206***b* for Topic **2**. Data sources have been omitted for the client **104** in the present example, but would interact with the illustrated components as previously described.

[0161] The client **106** includes a patron **208***a* for Topic **1** and a patron **208***b* for Topic **2**. The client **2108** includes a patron **208***c* for Topic **2**. Data destinations and brews **202** have been omitted from the clients **106** and **2108** in the present example, but would interact with the illustrated components as previously described.

[0162] The clients **104** and **106** communicate via ZeroMQ and the clients **104** and **2108** communicate via WebSockets. The brewers **206***a* and **206***b* send their data to both of the brews **202***a* and **202***b*.

[0163] Because the behavior of a brew **202** depends on the characteristics and requirements of the underlying module, each brew operates as needed for its module. For example, a ZeroMQ brew may use a separate socket on the corresponding module for each topic. This allows the brew to send/receive data for each topic via the corresponding socket. A Web Socket brew may be coupled to one or more WebSocket servers, and may use a different room for each topic. This means that "sending" involves writing to the appropriate room and "receiving" means reading from the appropriate room.

[0164] Because of differences between the brews **202***a* and **202***b*, the timing of various actions such as resource allocation may differ. For example, with respect to the brew **202***a*, the sockets **2102***a* and **2102***b* are created by the module **204***a* when the corresponding brewers **206***a* and **206***b* are created. This is specific to the ZeroMQ implementation of the brew **202***a*. In contrast, when the brew **202***b* is created, the module **204***b* creates the user resources. This is specific to the Web Sockets implementation of the brew **202***b*.

[0165] Accordingly, as illustrated in FIG. **21**, the module **204***a* includes a socket **2102***a* for Topic **1** and a socket **2102***b* for Topic **2**. More specifically, when each of the brewers **206***a* and **206***b* are created, a socket for their corresponding topic is created (or associated if already existing) in the ZeroMQ module **204***a* with the brewer's ID. The brew **202***a* can then link the brewers **206***a* and **206***b* with their corresponding sockets **2102***a* and **2102***b*, respectively, which enables the brew **202***a* to correctly route the data received from each brewer **206***a* and **206***b*.

[0166] The patron **208***a* is aware of the socket **2102***a* and is able to receive data from the socket **2102***a* via a ZeroMQ module and brew (not shown) of the client **106**. The patron **208***b* is aware of the socket **2102***b* and is able to receive data from the socket **2102***b* via the ZeroMQ module and brew of the client **106**.

[0167] In the present example, the WebSocket brew **202***b* writes to a room **2106** for Topic **2** on a Web Socket server **2104**. The patron **208***c* is aware of the room **2106** and is able to read data from the room **2106** via a Web Socket module and brew (not shown) of the client **2108**.

[0168] Referring to FIG. **22**, one embodiment of a system **2200** includes a Pubkeeper server **102***a* that is part of one Pubkeeper system (System **1**) and a Pubkeeper server **102***b* that is part of a different Pubkeeper system (System **2**). As shown the Pubkeeper client **104** communicates with both of the Pubkeeper servers **102***a* and **102***b*, which means that the application **302** only needs the single client to participate in both Pubkeeper systems.

[0169] Referring to FIG. **23**, one embodiment of a system **2300** includes a Pubkeeper server **102***a* that is part of one Pubkeeper system (System **1**) and a Pubkeeper server **102***b* that is part of a different Pubkeeper system (System **2**). In the present example, the application **302** uses two separate clients **104** and **106**. The client **104** communicates with the server **102***a* and the client **106** communicates with the server **102***b*.

[0170] Referring to FIG. **24**, one embodiment of a system **2400** includes a client **104**, a client **106**, and a client **2402**. As illustrated, the client **104** may communicate using message types **1**, **2**, and **3**. The client **106** can communicate using message types **1**, **2**, and **4**. The client **2402** can only communicate using message type **4**. This means that the clients **104** and **2402** cannot communicate directly. Accordingly, the client **106**, which can communicate with both the client **104** and the client **2402**, may relay communications between the two endpoints **104** and **2402**. For example, the client **106** may receive a message from one client, convert the message into the appropriate message type, and send the message to the other client. This allows the clients **104** and **2402** to participate fully in the Pubkeeper system and with each other without requiring additional message types to be added to the client **104** and/or the client **2402** for such communications.

[0171] Referring to FIGS. **25**A and **25**B, a system **2500** illustrates a more detailed embodiment of the system **2400** of FIG. **24**. The system **2500** enables the client **104** to communicate with the client **2502** via a bridge provided by the client **106**. For purposes of example, the client **104** includes a brewer that publishes using WebSockets, the client **2402** includes a patron that uses ZeroMQ and wants to receive information output by the brewer of the client **104**, and the client **106** can communicate using both WebSockets and ZeroMQ. The client **104** is not configured to use ZeroMQ, the client **2402** is not configured to use WebSockets, there are no compatible message types available between the clients **104** and **2402**, and the client **106** will be used to bridge the WebSocket/ZeroMQ gap. It is understood that these may be any message types and that Web Sockets and ZeroMQ are used only as examples.

[0172] The bridge client **106** represents a bridge segment that connects the client **104** to the client **2402**. The bridge segment is formed by a brewer and patron pair of the client **106**, with the bridge segment patron connecting to the brewer of the client **104** and the bridge segment brewer publishing to the patron of the client **2402**. While the data path illustrates data flowing from the client **104** to the client

2402, it is understood that communications may flow from the client **2402** to the client **104** in embodiments where the client **104** has a patron for a topic published by a brewer on the client **2402** and/or if needed for call setup or maintenance (e.g., for signaling). As will be shown in a later embodiment, there may be multiple bridge clients between the clients **104** and **2502** if needed to provide the necessary message types for the client **104** and **2402** to communicate.

[0173] A Pubkeeper server **102** (FIG. **25**A) is responsible for identifying the appropriate bridge client(s) and setting up the bridge segments needed to support the two clients **104** and **2402** that are trying to communicate. To facilitate this process, the server **102** may keep a list of orphans for the system **2500**. Each orphan represents a brewer or patron, along with the corresponding topic and message type, that does not have a matching patron or brewer, respectively. For example, the client **104** may have a brewer that publishes to a topic "sensor data" using WebSockets and the client **2402** may have a patron that uses only ZeroMQ but wants to subscribe to that topic. If there is no available bridge to connect the brewer to the patron, the server **102** will add the brewer and patron to the orphan list. When a new client comes online, the server **102** will check to see if the new client can provide a bridge for any of the orphans. If a desired bridge is made available by the new client, the server **102** will facilitate the bridging process and remove the corresponding orphans from the list. An orphan may remain on the list until a bridge is established, the client leaves the system **2500**, or the client closes the brewer or patron.

[0174] Depending on the particular implementation of bridge mode within the system **2500**, bridge mode may be optional for a particular client (e.g., opt-in or opt-out) or may be mandatory. If optional, bridge mode may be disabled by default and enabled only if a client registers with the server **102** to enable bridge mode. Bridge mode may be enabled by a client only for particular brews or for all brews that are supported by the client.

[0175] By providing control over bridge mode on a per client basis, clients that may be negatively impacted by bridging (e.g., clients with little or no extra processing power and/or the network capacity needed to handle bridge mode in addition to their assigned tasks) can be configured to refrain from bridging while clients that will not be negatively impacted can be used in bridge mode. As there will likely be additional resources available for bridging within the Pubkeeper system **2500**, a system may usually be planned normally and operate effectively without explicitly planning for each client to have the resources needed for bridge mode.

[0176] In the present embodiment, a client may be both a bridge client and a regular subscriber and/or publisher (e.g., may be configured to produce and/or consume information as part of the client's non-bridge mode operation) within the system **2500**. However, in other embodiments, clients that are regular subscribers and/or publishers may not be allowed to serve as bridge clients for security reasons. In such embodiments, a bridge client will exist only to handle bridging. In the present embodiment, the server **102** will not create a bridge node because the server **102** is not to be involved in the transmission of information for security reasons. However, in other embodiments, if no bridge is available, the server **102** may launch a client to serve as a bridge or may instruct another device to create a bridge client, or may override a client that has indicated that it does not want to be a bridge client and force the client into bridge mode.

[0177] As shown in FIG. **25**B, communications within the bridge client **106** (e.g., between the segment patron and segment brewer) are internal to the client **106**. For example, when creating the segment, the segment brewer may be created first and then the segment patron may be created with a callback to the segment brewer. This enables the segment patron to pass received data directly to the segment brewer within the client **106** and the data is not made available outside of the client **106**. More specifically, the segment patron receives the raw data from its assigned brew and passes the raw data to the segment brewer, which in turn sends the raw data out through its assigned brew.

[0178] Because decryption/encryption occur at the patron/brewer level in the present embodiment (rather than at the brew level as described in some previous embodiments), the segment patron and segment brewer are created with instructions to not decrypt or encrypt the raw data. This maintains the raw data in its original state, which means that the original encryption and decryption keys used by the origin brewer and destination patron remain valid. In addition, this prevents the data from being decrypted by a segment (which does not have the decryption key), thereby increasing the security of the transmitted data.

[0179] Referring to FIG. **26**, a sequence diagram **2600** illustrates one embodiment of a process by which the client **106** of FIGS. **25**A and **25**B may become a bridge between the clients **104** and **2402** within the Pubkeeper system **2500**. The internal behavior of the clients **104**, **106**, and **2402** is not illustrated as previous diagrams have described embodiments of such behavior. In addition, initial registration by the clients **104**, **106**, and **2402** with the server **102** has been omitted for purposes of clarity other than a brew registration message by the client **106**.

[0180] In the present example, due to the way in which the bridge is established, the client **104** and the client **2402** are unaware of the bridge client **106**. Accordingly, the brewer of the client **104** assumes that it is publishing directly to the destination that wants the data being published (e.g., the patron of the client **2402**). Similarly, the patron of the client **2402** assumes that it is subscribed directly to the origin of the data being received (e.g., the brewer of the client **104**). In other embodiments, one or both of the clients **104** and **2402** may be aware that the bridge client **106** is serving as an intermediary.

[0181] In step **2602**, the client **106** sends a brew registration message to the server **102**. The brew registration message may be part of a regular registration message (e.g., the message of step **718** of FIG. **7**) or may be a separate message. An example of a brew registration message for the client **106** is shown below.

```
{
  brews: [
      'websocket',
      'zmq'
  ],
  bridge_mode: True
}
```

[0182] The illustrated brew registration message informs the server **102** of all the brews that the client **106** will be

using and whether the client **106** is available as a bridge. In the present example, "bridge_mode: True" indicates that the client **106** is available as a bridge for the listed brews, while "bridge_mode: False" would indicate that the client **106** is not available as a bridge.

[0183] In some embodiments, the "true" or "false" indicator may be at least partly based on a status of each brew. For example, if a particular brew is unavailable and it is one of only two brews on that client **106**, then there can be no bridging. While the bridge mode status may still be set to true in this case, bridging would only occur if the client later notified the server of a second active brew. If there are three or more brews and at least two of those brews are functional, then the client **106** may be used as a bridge as long as the functional brews are the brews needed for bridging.

[0184] In some embodiments, the server **102** may be notified of the status of each brew at the time of registration, a later status message may be sent, or the server **102** may be notified of a non-functional brew only when the server **102** attempts to create a bridge using the brew. Accordingly, brew status may be used to indicate whether a particular brew is currently available. For example, ZeroMQ may have a status of "OK" or "ERROR."

[0185] In step **2604**, the server **102** identifies the client(s) to be used for bridge mode with the clients **104** and **2402**, which includes the client **106** in the present example. If multiple bridge possibilities are available, the server **102** may use the first available client, may calculate shortest/fastest path for bridge selection, may use the client(s) with the most available resources, and/or may choose the bridge client(s) in other ways.

[0186] In step **2606**, the server **102** sends a segment creation message to the client **106**. In the present example, the segment creation message instructs the client **106** to create a WebSocket patron and a ZeroMQ brewer that will be needed for the clients **104** and **2402**, respectively. An example of a segment creation message is as follows:

```
{
    'patron_details': {
        'patron_id': 'a1e88daacf58495a84000ce4ab166725',
        'prev_brewer_id': '19beb2a0e4094af1921ac3c17a3608de'
        'brew': {'sock': '/tmp/
19beb2a0e4094af1921ac3c17a3608de.sock', 'name': 'local-
83779604500539'},
        'topic': 'example.topic',
    },
    'brewer_details': {
        'brewer_id': '50176f68a6cf4fc38dfbb0e4e2c3f2c1'
        'brew_name': 'zmq',
        'topic': 'example.topic',
    },
    'segment_id': 'f9d43d33926147d9ac8be5dc0b0fc78e',
}
```

[0187] As shown, the segment creation message includes patron details for the bridge's patron, brewer details for the bridge's brewer, and a unique segment identifier. The patron details include a patron identifier that is assigned by the server **102**, the brewer from which the patron will receive information (prev_brewer_id), the brew that is used by the previous brewer and any relevant information so that the patron can subscribe to that brewer, and the topic (e.g., example_topic). The previous brewer may be the originating brewer (e.g., the brewer of the client **104**) or the brewer of the previous bridge in a chain of bridge clients (e.g., as shown in FIG. **27**).

[0188] The brewer details include a brewer identifier that is assigned by the server **102**, the name of the brew that the brewer is to use, and the topic. The topic name used by the brewer of the last bridge in a chain of bridges or a single bridge if only one bridge is used may be assigned using one of two different naming conventions. The first naming convention assigns the bridge's brewer topic the same name as that of the origination topic (e.g., the topic name used by the originating brewer of the client **104**). This allows the patron of the final destination client (e.g., the client **2402**) to subscribe to the topic using the original name. The second naming convention assigns the bridge's brewer topic a new name that does not match the originating brewer's topic, such as a randomized or otherwise selected name, and requires the final patron to subscribe to the assigned name. For example, rather than using the name "example.topic," the name may be assigned as "709d9eb2361842deae963f01c0365ea6."

[0189] The first naming convention enables the bridging process to occur without the final patron's knowledge. In other words, the patron of the client **2402** is subscribing to the same topic as that of the brewer of the client **104**. A potential downside is that in some embodiments, such as when a WebSocket server is being used, the bridge's brewer may be publishing into a room that may have multiple subscribers, some of which are subscribed directly to the originating brewer rather than the bridge's brewer. While the data being written to the room by the bridge's brewer is the same data that would be written to the room by the originating client's brewer, it is possible that complications might occur. For example, this process can technically nullify the WebSocket room's last value caching (if enabled), since the last value may be written by the bridge's brewer rather than the originating client's brewer.

[0190] The second naming convention provides a unique subscription channel for the final patron, but means that the final patron will be subscribing to the bridge brewer's topic name rather than the originating brewer's topic name. This exposes the destination client's patron to the bridging process because the destination client's patron is subscribing to a different topic name. This may complicate the process on the destination client's end, while solving the potential problems of the first naming convention. In the present example, the first naming convention is used.

[0191] In multi-bridge scenarios, topic names between bridges may be different from the originating brewer's topic name, but will generally be consistent between all the bridges. For example, the name "709d9eb2361842deae963f01c0365ea6" may be used between bridges even if the first naming convention is implemented and the final bridge's brewer uses the original topic name.

[0192] The unique segment identifier enables the server **102** to distinguish between different segments and enables the client **106** to support multiple simultaneous segments for different bridges, with each segment having a unique segment identifier. The use of uniquely identifiable segments enables the server **102** to instruct the client **106** to terminate or modify specific segments based on their identifiers.

[0193] In step **2608**, the client **106** creates the segment patron needed to receive information from the client **104** and

the segment brewer needed to publish information for the client **2402**. In step **2610**, the brewer and patron on the client **106** are registered with the server **102** for the segment identifier provided in the segment creation message of step **2606**. The segment registration of step **2610** may serve as a response to the segment creation message. An example of a segment registration message for the client **106** is as follows:

```
{
  'brewer_brew': {
      'publisher_url': 'tcp://127.0.0.1:9097',
      'name': 'zmq'
  },
  'patron_brew': {
      'name': 'local-83779604500539'
  },
  'segment_id': 'f9d43d33926147d9ac8be5dc0b0fc78e'
}
```

[0194] The segment registration message notifies the server **102** of the bridge's brewer and patron information, and identifies the bridge by its segment identifier. In step **2612**, the server **102** registers the information received from the client **106** in step **2610**.

[0195] In step **2614**, the server **102** sends a patron notify message to the client **104** to inform the client **104** of the segment patron of the client **106**. This message is similar or identical to the patron notification of step **1306** of FIG. **13**A.

[0196] In step **2616**, the server **102** sends a brewer notify message to the client **2402** to inform the client **2402** of the brewer of the client **106**. This message is similar or identical to the brewer notification of step **1402** of FIG. **14**A.

[0197] In step **2618**, the server **102** sends a segment connect brewer message to the client **106**. The segment connect brewer message serves as a patron notification to the client **106**, providing the brewer of the client **106** with the patron information of the next client (e.g., the client **2402**) in a manner similar to that of the patron notify of step **2614**. While the server **102** already knows the patron information needed by the brewer of the client **106** in the present example, the information is not sent until this time for consistency with multi-bridge embodiments where such information may not be known until each bridge segment is created. It is understood that the patron notify of step **2614**, the brewer notify of step **2616**, and the segment connect brewer message of step **2818** may be sent in a different order or simultaneously.

[0198] It is noted that there may not be an explicit brewer notification for the segment patron of the bridge client **106**, as the brewer notification may be an implicit part of the earlier segment creation message for that bridge client when the patron is created. In other words, by creating the patron and brewer on the bridge client **106** for the bridge segment, the patron is automatically aware of the existence of the corresponding brewer, which negates the need for an explicit brewer notify message for the patron.

[0199] Following step **2618**, the bridge segment is complete and data from the client **104** can be communicated to the client **2402** via a first leg from the origin brewer of the client **104** to the segment patron of the client **106**, between the segment patron and the segment brewer of the client **106**, and then via a second leg from the segment brewer of the client **106** to the destination patron of the client **2402**. To accomplish this, data corresponding to the desired topic that is published by the client **104** is received by the client **106** in step **2620**. In the present example, the data is received via WebSocket and is to be sent to the client **2402** via ZeroMQ. Accordingly, in step **2622**, the client **106** prepares the data for ZeroMQ transmission. It is understood that the data itself is generally not altered. For example, the data may be extracted from the payload of the incoming messages and inserted into the payload of outgoing messages and sent. This enables encrypted data to be received and relayed without alteration. In other embodiments, data may be altered if desired. In step **2624**, the data is sent to the client **2402**.

[0200] Referring to FIG. **27**, a system **2700** illustrates an embodiment of the system **2500** of FIGS. **25**A and **25**B with a second bridge client **2702**. In the present example, the client **104** publishes information via WebSockets and the client **2402** wants to receive the published information but only uses MQTT. The system **2700** does not include an available bridge client that uses both WebSockets and MQTT. However, the system **2700** includes the client **106** that uses WebSockets and ZeroMQ, and a client **2702** that uses ZeroMQ and MQTT. Accordingly, the client **106** can provide a Web Socket to ZeroMQ bridge segment and the client **2702** can provide a ZeroMQ to MQTT bridge segment to enable the client **2402** to receive the information published by the client **104**. It is understood that these may be any message types and that WebSockets, ZeroMQ, and MQTT are used only as examples.

[0201] Referring to FIGS. **28**A and **28**B, a sequence diagram **2800** illustrates one embodiment of a process by which the clients **106** and **2702** of FIG. **27** may be used to form a multi-segment bridge between the clients **104** and **2402** within the Pubkeeper system **2700**. The internal behavior of the clients **104**, **106**, **2402**, and **2702** is not illustrated as previous diagrams have described embodiments of such behavior. In addition, initial registration by the clients **104**, **106**, **2402**, and **2702** with the server **102** has been omitted for purposes of clarity, as have the brew registration messages by the clients **106** and **2702** (if different from the initial registration messages) and the segment registration by the server (e.g., step **2612** of FIG. **26**).

[0202] Steps **2802**, **2804**, **2806**, and **2808** correspond to steps **2604**, **2606**, **2608**, and **2610** of FIG. **26**, respectively, and are not described in detail in the present example. However, for the bridge-to-bridge communications between the clients **106** and **2702**, the topic for the brewer of the client **106** is assigned as "709d9eb2361842deae963f01c0365ea6" in the present example, rather than the "example.topic" name used with respect to FIG. **26**.

[0203] In step **2810**, the server **102** sends a segment creation message to the client **2702**. In the present example, the segment creation message instructs the client **2702** to create a ZeroMQ patron and a MQTT brewer that will be needed for the clients **106** and **2402**, respectively. An example of the segment creation message is as follows:

```
{
  'create_patron_details': {
      'patron_id': '409a7bcd09204691922bc77a50b769e4',
      'prev_brewer_id': '50176f68a6cf4fc38dfbb0e4e2c3f2c1',
      'brew': {
          'publisher_url': 'tcp://127.0.0.1:9097',
          'name': 'zmq'
      },
```

-continued

```
        'topic': '709d9eb2361842deae963f01c0365ea6',
    },
    'create_brewer_details': {
        'brewer_id': '78c3b261942f44bd894bbddda7de497b'.
        'brew_name': 'mqtt',
        'topic': 'example.topic',
    },
    'segment_id': '5a6f954a68f54de4b3629b5a1110f84e',
}
```

[0204] As shown, the segment creation message includes patron details for the bridge's patron, brewer details for the bridge's brewer, and a unique segment identifier. The patron details include a patron identifier that is assigned by the server **102**, the brewer from which the patron will receive information (e.g., the brewer of the bridge client **106**), the brew that is used by the previous brewer and any relevant information so that the patron can subscribe to that brewer, and the topic name. For purposes of example, the topic name that has been assigned to the brewer of the bridge **106** (e.g., in step **2804**) is "709d9eb2361842deae963f01c0365ea6." Accordingly, the topic to which the patron of the bridge client **2702** is to subscribe is "709d9eb2361842deae963f01c0365ea6." The brewer details include a brewer identifier that is assigned by the server **102**, the name of the brew that the brewer is to use, and the topic. The topic is named "example.topic," which is identical to the topic name used by the originating brewer of the client **104**.

[0205] In step **2812**, the client **2702** creates the segment patron needed to receive information from the bridge client **106** and the segment brewer needed to publish information for the client **2402**. In step **2814**, the brewer and patron on the client **2702** are registered with the server **102** for the segment identifier provided in the segment creation message of step **2810**. An example of a segment registration message for the client **2702** is as follows:

```
{
    'brewer_brew': {
        'publisher_url': 'tcp://127.0.0.1:9171',
        'name': 'mqtt'
    },
    'patron_brew': {
        'name': 'zmq'
    },
    'segment_id': '5a6f954a68f54de4b3629b5a1110f84e'
}
```

[0206] In steps **2816** and **2818**, the server **102** sends segment connect brewer messages to the bridge clients **106** and **2702**, respectively. Because the server **102** may not have all the needed information for the bridge clients until both bridge clients have created their respective brewers, the segment connect brewer message are sent following the receipt of the segment registration messages by the server **102**. An example of the segment connect brewer message for the client **106** is as follows:

```
{
    'patron_id': '409a7bcd09204691922bc77a50b769e4',
    'patron_brew': {
        'name': 'zmq'
    },
    'segment_id': 'f9d43d33926147d9ac8be5dc0b0fc78e'}
```

[0207] This message informs the client **106** of the existence of the patron of the client **2702** and the brew used by that patron. It is noted that there is not an explicit brewer notify for the segment patron of the bridge client, as the brewer notification is an implicit part of the earlier segment creation message for that bridge client when the patron is created.

[0208] An example of the segment connect brewer message for the client **2702** is as follows:

```
{
    'patron_id': '2708dd30f67b4b018f2817119adbdc5e',
    'patron_brew': {
        'name': 'mqtt'
    },
    'segment_id': '5a6f954a68f54de4b3629b5a1110f84e'}
```

[0209] This message informs the client **2702** of the patron of the client **2402** and the brew used by that patron.

[0210] In steps **2820** and **2822**, respectively, a patron notification is sent to the client **104** and a brewer notification is sent to the client **2402**. It is understood that the segment connect brewer messages of steps **2816** and **2818**, the patron notify of step **2820**, and the brewer notify of step **2822** may be sent in a different order or simultaneously.

[0211] Following step **2622**, the bridge segments are complete and data from the client **104** can be communicated to the client **2402**. To accomplish this, data corresponding to the desired topic that is published by the client **104** is received by the client **106** in step **2826**. In the present example, the data is received via Web Socket and is to be published via ZeroMQ. Accordingly, in step **2826**, the client **106** prepares the data for ZeroMQ transmission. The data is published by the client **106** and received by the client **2702** in step **2828**. In the present example, the data is received via ZeroMQ and is to be published by the client **2702** via MQTT. Accordingly, in step **2830**, the client **2702** prepares the data for MQTT transmission. In step **2832**, the data is sent to the client **2402**.

[0212] Referring to FIG. **29**, a method **2900** illustrates one embodiment of a process that may be performed within a Pubkeeper system by a Pubkeeper server (e.g., the server **102** of FIGS. **25**A or **27**) to establish one or more bridge segments. In the present example, the server **102** maintains an orphan list with patrons and brewers that have no current match and for which there are no compatible bridge clients registered with the server **102**.

[0213] In step **2902**, a bridge client registers. As previously described, the registration provides information to the server **102**, including the brews supported by the registering bridge client. In steps **2904** and **2906**, the server **102** determines whether the newly registered bridge client can be used to link any of the patrons and/or brewers on the orphan list. If no matches are available (e.g., if the bridge client cannot be used with any of the current orphans), the method **2900** continues to step **2908**. In step **2908**, the server **102** waits for another bridge client to register, at which time the method **2900** returns to step **2902**.

[0214] If a match is available (e.g., if the server **102** can build a bridge for an orphan using one or more available bridge clients), the method **2900** moves from step **2906** to step **2910**. For each bridge client to be used in creating a bridge, the server **102** sends a segment creation message to the client in step **2910** and receives a segment registration message from the client in step **2912**. As these messages have been described in previous embodiments, they are not described in detail in the present example.

[0215] In step **2914**, the server **102** sends a segment connect brewer message to each bridge client. Although shown following the receipt of all segment registrations of step **2912**, a segment connect brewer message may be sent to a bridge client once the server **102** has any needed information from a particular segment registration message, even if other segment registration messages have not been received. In step **2916**, the server **102** sends patron and brewer notification messages to the origin and destination clients, respectively. Steps **2916** and **2918** may occur in a different order or simultaneously.

[0216] In step **2918**, the server **102** removes the origin brewer and/or destination patron from the orphan list. Step **2918** may occur earlier in the method **2900** (e.g., immediately following step **2906**), but is shown in its current location to ensure the orphan list is not updated until the bridge is in place.

[0217] Referring to FIG. **30**, a method **3000** illustrates one embodiment of a process that may be performed within a Pubkeeper system by a bridge client (e.g., the client **106** of FIGS. **24**, **25**A, **25**B, or **27**) to establish a bridge segment. The client **106** may be the only bridge segment (e.g., as in FIGS. **25**A and **25**B) or may be one of multiple bridge segments (e.g., as in FIG. **27**).

[0218] In step **3002**, the bridge client **106** registers with the server **102** as a bridge client, which includes notifying the server **102** of the brews that the client **106** has available. In step **3004**, which may occur at any time following step **3002**, the client **106** receives a segment creation message. As previously described, the segment creation message instructs the client **106** to create a patron and brewer for a segment using particular brews. In step **3006**, the client **106** creates the segment patron and segment brewer using the defined brews. In step **3008**, the client **106** sends a segment registration message to the server **102**. The segment registration message notifies the server **102** that the client **106** has created the segment patron and segment brewer, and provides any patron/brewer specific information that may be needed by the server **102** while setting up the bridge.

[0219] In step **3010**, the client **106** receives a segment connect brewer message. The segment connect brewer message activates the segment patron and provides any information that may be needed by the patron and/or brewer. In step **3012**, the segment patron of the client **106** connects to the brewer of the previous client (either the origin client or a preceding bridge client). In step **3014**, the client **106** receives and repackages data from the previous brewer. In step **3016**, the client **106** republishes the data via the segment brewer.

[0220] Referring to FIG. **31**A, a sequence diagram **3100** illustrates embodiments of two different processes (separated by a line **3122**) that may be used by the system **2700** of FIG. **27** to handle a disconnect by an origin brewer or a destination patron. The first process begins with step **3102** and illustrates an origin brewer disconnection. The second process begins with step **3112** and illustrates a destination patron disconnection. It is understood that if no initial disconnect message is sent to the server **102** (e.g., if the client **104** or the client **2402** crashes), the server **102** may detect the disconnect and perform the steps shown following a disconnect message. Although shown with two segments, it is understood that the sequence diagram **3100** is equally applicable to single segment bridges such as that shown in FIG. **25**A.

[0221] In step **3102**, the client **104** sends a disconnect message for the origin brewer. In step **3104**, the server **102** identifies any bridge clients with related segments. In steps **3106** and **3108**, the server **102** notifies the clients **2702** and **106**, respectively, to terminate their corresponding segments. In step **3110**, the server **102** sends a brewer removal notification to the client **2402** to inform the client **2402** that the brewer to which the destination patron was listening is no longer available. It is understood that the messages of steps **3106**, **3108**, and **3110** may occur in a different order or simultaneously.

[0222] In step **3112**, the client **2402** sends a disconnect message for the destination patron. In step **3114**, the server **102** identifies any bridge clients with related segments. In steps **3116** and **3118**, the server **102** notifies the clients **2702** and **106**, respectively, to terminate their corresponding segments. In step **3120**, the server **102** sends a patron removal notification to the client **104** to inform the client **104** that the patron to which the origin brewer was publishing is no longer available. It is understood that the messages of steps **3116**, **3118**, and **3120** may occur in a different order or simultaneously.

[0223] Referring to FIG. **31**B, a sequence diagram **3130** illustrates embodiments of two different processes (separated by a line **3152**) that may be used by the system **2700** of FIG. **27** to handle a disconnect by a bridge client. The first process begins with step **3132** and illustrates a disconnection that automatically results in the entire bridge being terminated. The second process begins with step **3142** and illustrates a disconnection in which the server **102** attempts to repair the bridge. It is understood that if no initial disconnect message is sent to the server **102** (e.g., if the bridge client **106** or **2702** crashes), the server **102** may detect the disconnect and perform the steps shown following a disconnect message. Although shown with two segments, it is understood that the sequence diagram **3130** is equally applicable to single segment bridges such as that shown in FIG. **25**A.

[0224] In step **3132**, the bridge client **106** sends a disconnect message for the bridge segment. The disconnect message may indicate that the client **106** is disconnecting entirely or that the segment is being terminated by the client **106**. In step **3134**, the server **102** identifies any bridge clients with related segments. In step **3136**, the server **102** notifies the client **2702** to terminate the corresponding segment. In step **3138**, the server **102** sends a patron removal notification to the client **104**. In step **3140**, the server **102** sends a brewer removal notification to the client **2402**. It is understood that the messages of steps **3136**, **3138**, and **3140** may occur in a different order or simultaneously.

[0225] In step **3142**, the bridge client **106** sends a disconnect message for the bridge segment. The disconnect message may indicate that the client **106** is disconnecting entirely or that the segment is being terminated by the client **106**. In step **3144**, the server **102** determines that a substitute bridge is available. In step **3146**, the server **102** sets up a new

segment using the substitute bridge (not shown). As the substitute segment is created as a regular segment and such setup steps have been previously described, the setup process is not shown in FIG. **31**B.

[0226] In step **3148**, the server **102** sends a segment update to the bridge client **2702** so that the client **2702** will have the information for the new segment (e.g., the brewer information needed by the segment patron of the client **2702**). In step **3150**, the server **102** sends a patron update to the client **104**. It is understood that the messages of steps **3148** and **3150** may occur in a different order or simultaneously.

[0227] If the disconnect of step **3142** was sent by the bridge client **2702**, the message of step **3148** would be sent to the client **106** and a brewer update would be sent to the client **2402**. It is understood that updates may be sent to all clients involved in the bridge or just to clients that are adjacent to, or otherwise affected by the introduction of, a substitute node. If the determination of step **3144** does not identify a substitute bridge client, the bridge would be terminated as illustrated in steps **3134** through **3140**.

[0228] Referring to FIG. **32**A, a method **3200** illustrates one embodiment of a process that may be performed within a Pubkeeper system by a server (e.g., the server **102** of FIGS. **24**, **25**A, or **27**) when a bridge client disconnects. The method **3200** may be used with both single segment and multi-segment bridges. In the present example, the entire bridge is terminated if any segment disconnects.

[0229] In step **3202**, the server **102** detects that a bridge client or segment has disconnected or receives a notification of such a disconnection. In step **3204**, the server **102** sends a segment termination message to any bridge clients that are providing other segments for the bridge. In step **3206**, the server **102** sends a patron removal message to the client with the origin brewer and a brewer removal message to the client with the destination patron. In step **3208**, the origin brewer and destination patron are added to the orphan list.

[0230] Referring to FIG. **32**B, a method **3210** illustrates one embodiment of a process that may be performed within a Pubkeeper system by a server (e.g., the server **102** of FIGS. **24**, **25**A, or **27**) when a bridge's destination patron disconnects. The method **3210** may be used with both single segment and multi-segment bridges.

[0231] In step **3212**, the server **102** detects that the destination patron has disconnected or receives a notification of such a disconnection. In step **3214**, the server **102** sends a termination message to any bridge clients that are providing other segments for the bridge. In step **3216**, the server **102** sends a patron removal message to the client with the origin brewer.

[0232] Referring to FIG. **32**C, a method **3220** illustrates one embodiment of a process that may be performed within a Pubkeeper system by a server (e.g., the server **102** of FIGS. **24**, **25**A, or **27**) when a bridge's origin brewer disconnects. The method **3220** may be used with both single segment and multi-segment bridges.

[0233] In step **3222**, the server **102** detects that the origin brewer has disconnected or receives a notification of such a disconnection. In step **3224**, the server **102** sends a termination message to any bridge clients that are providing other segments for the bridge. In step **3226**, the server **102** sends a brewer removal message to the client with the destination patron.

[0234] Referring to FIGS. **33**A and **33**B, a method **3300** illustrates one embodiment of a process that may be performed within a Pubkeeper system by a server (e.g., the server **102** of FIGS. **24**, **25**A, or **27**) when a bridge client disconnects. As disconnection by the origin brewer or destination patron results in the entire bridge being terminated, the present example applies only when a bridge segment disconnects. The method **3300** may be used with both single segment and multi-segment bridges.

[0235] In step **3302**, the server **102** detects that a bridge client or segment has disconnected or receives a notification of a disconnection. It is noted that a segment may disconnect even if the bridge client supporting that segment remains online if, for example, one of the brews supporting the segment enters an error state. In step **3304**, the server **102** attempts to locate another bridge client to serve as a substitute for the disconnected segment. For example, if the segment was supporting ZeroMQ to MQTT, the server **102** may determine whether another bridge client is available that can support a ZeroMQ to MQTT segment. If a match is found, as determined in step **3306**, the method moves to step **3308**.

[0236] In step **3308**, the server **102** sends a segment creation message to the substitute bridge client. In step **3310**, the server **102** receives a segment registration message from the substitute bridge. In step **3312**, the server **102** sends updated segment brewer connect messages to existing bridge clients as needed. In some embodiments the server **102** may send segment brewer connect messages to all existing bridge clients, while in other embodiments the server **102** may only send necessary segment brewer connect messages (e.g., to the bridge client preceding the substitute bridge client). It is understood that step **3312** may be omitted entirely when dealing with single segment bridges as no other bridge clients exist.

[0237] In step **3314**, patron and/or brewer update messages may be sent to the origin and destination clients, respectively, as needed. For example, if the new segment immediately follows the origin brewer in the bridge, the origin brewer may be updated with the new segment's patron information. Similarly, if the destination patron immediately follows the new segment, the destination patron may be updated with the new segment's brewer information. If the new segment is between two bridge clients, then neither the origin brewer nor the destination patron may be updated. However, in some embodiments, updates may be sent to the origin brewer and the destination patron even if such updates are not needed. For example, this may be done to maintain messaging consistency and/or to account for possible scenarios in which such updates are useful.

[0238] Returning to step **3306**, if no match is found, the method **3300** moves to step **3316** rather than step **3308**. In step **3316**, the server **102** sends termination messages for any related segments because there is no substitute for the disconnected segment. In step **3318**, the server **102** sends a patron removal message to the client with the origin brewer and a brewer removal message to the client with the destination patron.

[0239] At this point, the bridge has been completely terminated and the origin brewer and destination patron may be added to the orphan list. However, in the present example, the server **102** attempts to create a new bridge in step **3320**. For example, even though the disconnected segment cannot be replaced, another bridge may be available that does not need the brews provided by the missing segment. If a new

bridge is available as determined in step **3322**, the method **3300** moves to step **3324**. In step **3324**, the new bridge is created. If no new bridge is available, the method **3300** moves to step **3326** and the origin brewer and destination patron are added to the orphan list.

[0240] Referring to FIG. **34**, one embodiment of a system **3400** includes clients **3402**, **3404**, **3406**, and **3408** and illustrates multiple brewers publishing to a single bridge client. The clients **3402** and **3404** are both publishing via a JavaScript brew to the client **3406**, which is serving as a bridge client. The client **3406** is publishing the received data via Python to the client **3408**.

[0241] Referring to FIG. **35**, one embodiment of a system **3500** includes clients **3502**, **3504**, **3506**, and **3508** and illustrates multiple patrons listening to a single bridge client. The client **3502** is publishing via a JavaScript brew to the client **3504**, which is serving as a bridge client. The client **3504** is publishing via Python to the clients **3506** and **3508**. In some embodiments, the server **102** (FIGS. **25**A and **27**) may use the client **3504** to broadcast a single topic to multiple patrons (e.g., the patrons of the client **3506** and **3508**) in order to avoid the need for multiple bridges for a single topic.

[0242] Referring to FIG. **36**, one embodiment of a system **3600** includes a Pubkeeper system **3602** containing a gateway **3604**. The gateway **3604** is coupled to a device **3606**. The device **3606** may lack or have minimal IP communications capabilities, and/or may have no or limited access to a network necessary to communicate as a client within the Pubkeeper system **3602**.

[0243] Referring to FIG. **37**, one embodiment of a device **3700** is illustrated. The device **3700** is one possible example of one or more of the devices **108**, **110**, and **112** of FIG. **1**A. The device **3700** may include a controller (e.g., a processor/central processing unit ("CPU")) **3702**, a memory unit **3704**, an input/output ("I/O") device **3706**, and a network interface **3708**. The components **3702**, **3704**, **3706**, and **3708** are interconnected by a data transport system (e.g., a bus) **3710**. A power supply (PS) **3712** may provide power to components of the device **3700** via a power transport system **3714** (shown with data transport system **3710**, although the power and data transport systems may be separate).

[0244] It is understood that the device **3700** may be differently configured and that each of the listed components may actually represent several different components. For example, the CPU **3702** may actually represent a multiprocessor or a distributed processing system; the memory unit **3704** may include different levels of cache memory, main memory, hard disks, and remote storage locations; the I/O device **3706** may include monitors, keyboards, touchpads, and the like; and the network interface **3708** may include one or more network chips or cards providing one or more wired and/or wireless connections to a network **3716**. Therefore, a wide range of flexibility is anticipated in the configuration of the device **3700**, which may range from a single physical platform configured primarily for a single user or autonomous operation to a distributed multi-user platform such as a cloud computing system.

[0245] The device **3700** may use any operating system (or multiple operating systems), including various versions of operating systems provided by Microsoft (such as WINDOWS), Apple (such as MacOS), UNIX, and LINUX, and may include operating systems specifically developed for handheld devices (e.g., i**0**S, Android, Blackberry, and/or Windows Phone), personal computers, servers, and other computing platforms depending on the use of the device **3700**. The operating system, as well as other instructions (e.g., for telecommunications and/or other functions provided by the device), may be stored in the memory unit **3704** and executed by the processor **3702**. For example, if the device **3700** is the device **110**, the memory unit **3704** may include instructions for providing the Pubkeeper server **102** and/or client **104** and for performing some or all of the processes described herein.

[0246] The network **3716** (which may be the network(s) **114** of FIG. **1**A) may be a single network or may represent multiple networks, including networks of different types, whether wireless or wireline. For example, the device **3700** may be coupled to external devices via a network that includes a cellular link coupled to a data packet network, or may be coupled via a data packet link such as a wide local area network (WLAN) coupled to a data packet network or a Public Switched Telephone Network (PSTN). Accordingly, many different network types and configurations may be used to couple the device **3700** with external devices.

[0247] Exemplary network, system, and connection types include the internet, WiMax, local area networks (LANs) (e.g., IEEE 802.11a and 802.11g wi-fi networks), digital audio broadcasting systems (e.g., HD Radio, T-DMB and ISDB-TSB), terrestrial digital television systems (e.g., DVB-T, DVB-H, T-DMB and ISDB-T), WiMax wireless metropolitan area networks (MANs) (e.g., IEEE 802.16 networks), Mobile Broadband Wireless Access (MBWA) networks (e.g., IEEE 802.20 networks), Ultra Mobile Broadband (UMB) systems, Flash-OFDM cellular systems, and Ultra wideband (UWB) systems. Furthermore, the present disclosure may be used with communications systems such as Global System for Mobile communications (GSM) and/or code division multiple access (CDMA) communications systems. Connections to such networks may be wireless or may use a line (e.g., digital subscriber lines (DSL), cable lines, and fiber optic lines).

[0248] Accordingly, in one embodiment, the present disclosure describes a client configured to operate within a messaging system that enables the use of a plurality of message types, the client comprising system functionality that enables the client to operate within the messaging system in order to send and receive messages for an application that is using the client; at least one brew that is configured to manage one of the plurality of message types for the client by interacting with a module that encapsulates a process for sending and receiving messages within the messaging system that are compliant with the message type, wherein the brew provides a brew interface for interaction with at least one brewer of the client, and wherein the brew interface is standardized across all brews within the client to enable any brewers of the client to send messages to the brews in an identical manner regardless of the process encapsulated by the module that is being managed by each brew; and at least one brewer that is associated with a topic and provides a brewer interface for receiving outgoing data corresponding to the topic from the application, wherein the brewer is configured to send the outgoing data to the brew, and wherein the brewer interface is standardized across all brewers within the client to enable the application to send messages to the brewers in an identical manner.

[0249] In some embodiments, the brew is configurable to push data directly to the application.

[0250] In some embodiments, the brewer is configured to notify at least one of the brews that a patron corresponding to the topic has been registered within the messaging system by another client, wherein the brew establishes a connection via the module with a corresponding brew and module of the other client based on the notification in order to send data for the topic to the other client.

[0251] In some embodiments, the client further comprises at least one patron that is associated with a topic and is configured to notify at least one of the brews that a brewer corresponding to the topic has been registered within the messaging system by another client, wherein the brew establishes a connection via the module with a corresponding brew and module of the other client based on the notification in order to receive data for the topic from the other client.

[0252] In some embodiments, the client further comprises at least one patron that is associated with a topic and configured to receive incoming data corresponding to the topic from the brew, wherein the patron provides a patron interface from which the application can pull the incoming data from the patron, and wherein the patron interface is standardized across all patrons within the client.

[0253] In some embodiments, the patron is configurable to push data to the application.

[0254] In some embodiments, the module is configured to send the outgoing data directly to a module of another client in a peer-to-peer manner.

[0255] In some embodiments, the module is configured to send the outgoing data to a server for retrieval by a module of another client.

[0256] In some embodiments, the brew is configured to perform processing to format the outgoing data and the incoming data.

[0257] In some embodiments, the brew is configured to perform processing to encrypt the outgoing data and decrypt the incoming data.

[0258] In another embodiment, the present disclosure describes a client configured to operate within a messaging system that enables the use of a plurality of message types, the client comprising system functionality that enables the client to operate within the messaging system in order to send and receive messages for an application that is using the client; at least one brew that is configured to manage one of the plurality of message types for the client by interacting with a module that encapsulates a process for sending and receiving messages within the messaging system that are compliant with the message type, wherein the brew provides a brew interface for interaction with at least one patron of the client, wherein the brew interface is standardized across all brews within the client to enable any patrons of the client to interact with the brews in an identical manner regardless of the process encapsulated by the module that is being managed by each brew; and at least one patron that is associated with a topic and is configured to notify at least one of the brews that a brewer corresponding to the topic has been registered within the messaging system by another client, wherein the brew establishes a connection via the module with a corresponding brew and module of the other client based on the notification in order to receive data for the topic from the other client.

[0259] In some embodiments, the patron provides a patron interface from which the application can pull the incoming data from the patron, and wherein the patron interface is standardized across all patrons within the client.

[0260] In some embodiments, the patron is configurable to push data to the application.

[0261] In some embodiments, the brew is configurable to push data directly to the application.

[0262] In some embodiments, the client further comprises at least one brewer that is associated with a topic and provides a brewer interface for receiving outgoing data corresponding to the topic from the application, wherein the brewer is configured to send the outgoing data to the brew, and wherein the brewer interface is standardized across all brewers within the client.

[0263] In some embodiments, the brewer is configured to notify at least one of the brews that a patron corresponding to the topic has been registered within the messaging system by another client, wherein the brew establishes a connection via the module with a corresponding brew and module of the other client based on the notification in order to send data for the topic to the other client.

[0264] In some embodiments, the module is configured to send the outgoing data directly to a module of another client in a peer-to-peer manner.

[0265] In some embodiments, the module is configured to send the outgoing data to a server room for retrieval by a module of another client.

[0266] In some embodiments, the brew is configured to perform processing to format the outgoing data and the incoming data.

[0267] In some embodiments, the brew is configured to perform processing to encrypt the outgoing data and decrypt the incoming data.

[0268] In another embodiment, the present disclosure describes a system for enabling the management of a plurality of message types through a common interface, the system comprising a server configured to manage messaging information for a plurality of clients; and the plurality of clients, wherein each client includes a plurality of brews that are registered with the client, wherein each brew is configured to manage one of a plurality of message types for the client by interacting with a module that encapsulates a process for sending and receiving messages of the message type, and wherein the brew provides an interface between the module and a plurality of brewers and patrons to enable sending and receiving data, respectively, via the module in compliance with the message type, and wherein the brew is configurable to send incoming data directly to an application that is using the client; the plurality of brewers, wherein each brewer is associated with at least one topic and provides an interface for receiving outgoing data corresponding to the topic from the application and sending the outgoing data to at least one of the plurality of brews; and the plurality of patrons that are registered with the client, wherein each patron is associated with a topic and is configurable to provide an interface for receiving incoming data corresponding to a topic from at least one of the plurality of brews and sending the incoming data to the application.

[0269] In another embodiment, the present disclosure describes a method for use by a client in a messaging system that supports multiple message types, the method comprising starting, by an application, a client process in order to launch the client; creating and configuring at least one brew for use by the client, wherein the brew is configured to manage one of a plurality of message types for the client by

interacting with a module that encapsulates a process for sending and receiving messages of the message type; creating and configuring the module corresponding to each brew; creating and configuring at least one of a brewer for sending outgoing data or a patron for receiving incoming data; registering the at least one brewer or patron with a server of the messaging system; receiving a list including at least one patron or brewer from the server; and performing at least one of sending outgoing data for the application or receiving incoming data for the application.

[0270] In some embodiments, the client includes a brewer, the method further comprising receiving a notification of a new patron at another client within the messaging system; notifying the brew of the new patron; and connecting, by the brew via the module, with a module and brew of the other client in order to send outgoing data from the application to the other client.

[0271] In some embodiments, the client includes a patron, the method further comprising receiving a notification of a new brewer at another client within the messaging system; notifying the brew of the new brewer; and connecting, by the brew via the module, with a module and brew of the other client in order to receive incoming data for the application from the other client.

[0272] In another embodiment, the present disclosure describes a method for creating a bridge segment within a messaging system that supports the use of a plurality of message types, the method comprising maintaining an orphan list that contains at least one pair of incompatible brewers and patrons within the messaging system, wherein each pair on the orphan list includes a brewer configured to publish data for a topic and a list of all message types supported by the client corresponding to the brewer; and a patron configured to subscribe to the topic and a list of all message types supported by the client corresponding to the patron, wherein the patron cannot communicate directly with the brewer because the clients corresponding to the brewer and the patron do not share a compatible message type; identifying, for a first pair on the orphan list formed by a first brewer and a first patron, a bridge client that can communicate with a first client corresponding to the first brewer and a second client corresponding to the first patron, wherein the first client uses a first message type and the second client uses a second message type; instructing the bridge client to create a bridge segment by starting a segment patron that uses the first message type and a segment brewer that uses the second message type, wherein the bridge patron and the bridge client are linked together within the bridge client; receiving a notification from the bridge client that the bridge segment has been created; and notifying the first client of the bridge patron and the second client of the bridge brewer, wherein communication between the first and second clients is enabled via a channel formed between the first brewer and the bridge patron using the first message type, the bridge segment, and the bridge brewer and the first patron using the second message type.

[0273] In another embodiment, the present disclosure describes a method for creating a bridge between incompatible clients within a messaging system that supports the use of a plurality of message types, the method comprising maintaining an orphan list that stores pairs of incompatible brewers and patrons that exist within the messaging system, wherein each pair on the orphan list includes an origin brewer configured to publish data for a topic and a list of all message types supported by a client corresponding to the origin brewer; and a destination patron configured to subscribe to the topic and a list of all message types supported by the client corresponding to the destination patron, wherein the destination patron cannot communicate directly with the origin brewer because the clients corresponding to the origin brewer and the destination patron do not share a compatible message type; identifying a plurality of bridge clients available within the messaging system that can be used to create a bridge between the origin brewer and the destination patron of a first pair on the orphan list, wherein the bridge will include a plurality of bridge segments that are each provided by one of the bridge clients, and wherein each of the bridge clients supports two different message types needed for the bridge; for each bridge segment, instructing the corresponding bridge client to create the bridge segment by starting a segment patron that uses the one of the two message types that is needed as an input and a segment brewer that uses the other of the two message types that is needed as an output, wherein the segment patron and the segment client are linked together within the bridge client; for each bridge segment, notifying each bridge client of an immediately preceding brewer in the bridge to which the segment patron should subscribe and an immediately following patron in the bridge that is to receive data published by the segment brewer; and notifying the origin brewer of the following segment patron and notifying the destination patron of the preceding segment brewer.

[0274] While the preceding description shows and describes one or more embodiments, it will be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the spirit and scope of the present disclosure. For example, various steps illustrated within a particular flow chart may be combined or further divided. In addition, steps described in one diagram or flow chart may be incorporated into another diagram or flow chart. Furthermore, the described functionality may be provided by hardware and/or software, and may be distributed or combined into a single platform. Additionally, functionality described in a particular example may be achieved in a manner different than that illustrated, but is still encompassed within the present disclosure. Therefore, the claims should be interpreted in a broad manner, consistent with the present disclosure.

What is claimed is:

1. A client configured to operate within a messaging system that enables the use of a plurality of message types, the client comprising:

system functionality that enables the client to operate within the messaging system in order to send and receive messages for an application that is using the client;

at least one brew that is configured to manage one of the plurality of message types for the client by interacting with a module that encapsulates a process for sending and receiving messages within the messaging system that are compliant with the message type, wherein the brew provides a brew interface for interaction with at least one brewer of the client, and wherein the brew interface is standardized across all brews within the client to enable any brewers of the client to send messages to the brews in an identical manner regardless of the process encapsulated by the module that is being managed by each brew; and

at least one brewer that is associated with a topic and provides a brewer interface for receiving outgoing data corresponding to the topic from the application, wherein the brewer is configured to send the outgoing data to the brew, and wherein the brewer interface is standardized across all brewers within the client to enable the application to send messages to the brewers in an identical manner.

2. The client of claim **1** wherein the brew is configurable to push data directly to the application.

3. The client of claim **1** wherein the brewer is configured to notify at least one of the brews that a patron corresponding to the topic has been registered within the messaging system by another client, wherein the brew establishes a connection via the module with a corresponding brew and module of the other client based on the notification in order to send data for the topic to the other client.

4. The client of claim **1** further comprising at least one patron that is associated with a topic and is configured to notify at least one of the brews that a brewer corresponding to the topic has been registered within the messaging system by another client, wherein the brew establishes a connection via the module with a corresponding brew and module of the other client based on the notification in order to receive data for the topic from the other client.

5. The client of claim **1** further comprising at least one patron that is associated with a topic and configured to receive incoming data corresponding to the topic from the brew, wherein the patron provides a patron interface from which the application can pull the incoming data from the patron, and wherein the patron interface is standardized across all patrons within the client.

6. The client of claim **5** wherein the patron is configurable to push data to the application.

7. The client of claim **1** wherein the module is configured to send the outgoing data directly to a module of another client in a peer-to-peer manner.

8. The client of claim **1** wherein the module is configured to send the outgoing data to a server for retrieval by a module of another client.

9. The client of claim **1** wherein the brew is configured to perform processing to format the outgoing data and the incoming data.

10. The client of claim **1** wherein the brew is configured to perform processing to encrypt the outgoing data and decrypt the incoming data.

11. A client configured to operate within a messaging system that enables the use of a plurality of message types, the client comprising:

system functionality that enables the client to operate within the messaging system in order to send and receive messages for an application that is using the client;

at least one brew that is configured to manage one of the plurality of message types for the client by interacting with a module that encapsulates a process for sending and receiving messages within the messaging system that are compliant with the message type, wherein the brew provides a brew interface for interaction with at least one patron of the client, wherein the brew interface is standardized across all brews within the client to enable any patrons of the client to interact with the brews in an identical manner regardless of the process encapsulated by the module that is being managed by each brew; and

at least one patron that is associated with a topic and is configured to notify at least one of the brews that a brewer corresponding to the topic has been registered within the messaging system by another client, wherein the brew establishes a connection via the module with a corresponding brew and module of the other client based on the notification in order to receive data for the topic from the other client.

12. The client of claim **11** further wherein the patron provides a patron interface from which the application can pull the incoming data from the patron, and wherein the patron interface is standardized across all patrons within the client.

13. The client of claim **12** wherein the patron is configurable to push data to the application.

14. The client of claim **11** wherein the brew is configurable to push data directly to the application.

15. The client of claim **11** further comprising at least one brewer that is associated with a topic and provides a brewer interface for receiving outgoing data corresponding to the topic from the application, wherein the brewer is configured to send the outgoing data to the brew, and wherein the brewer interface is standardized across all brewers within the client.

16. The client of claim **11** wherein the brewer is configured to notify at least one of the brews that a patron corresponding to the topic has been registered within the messaging system by another client, wherein the brew establishes a connection via the module with a corresponding brew and module of the other client based on the notification in order to send data for the topic to the other client.

17. The client of claim **11** wherein the module is configured to send the outgoing data directly to a module of another client in a peer-to-peer manner.

18. The client of claim **11** wherein the module is configured to send the outgoing data to a server room for retrieval by a module of another client.

19. The client of claim **11** wherein the brew is configured to perform processing to format the outgoing data and the incoming data.

20. A system for enabling the management of a plurality of message types through a common interface, the system comprising:

a server configured to manage messaging information for a plurality of clients; and

the plurality of clients, wherein each client includes

a plurality of brews that are registered with the client, wherein each brew is configured to manage one of a plurality of message types for the client by interacting with a module that encapsulates a process for sending and receiving messages of the message type, and wherein the brew provides an interface between the module and a plurality of brewers and patrons to enable sending and receiving data, respectively, via the module in compliance with the message type, and wherein the brew is configurable to send incoming data directly to an application that is using the client;

the plurality of brewers, wherein each brewer is associated with at least one topic and provides an inter-

face for receiving outgoing data corresponding to the topic from the application and sending the outgoing data to at least one of the plurality of brews; and

the plurality of patrons that are registered with the client, wherein each patron is associated with a topic and is configurable to provide an interface for receiving incoming data corresponding to a topic from at least one of the plurality of brews and sending the incoming data to the application.

* * * * *