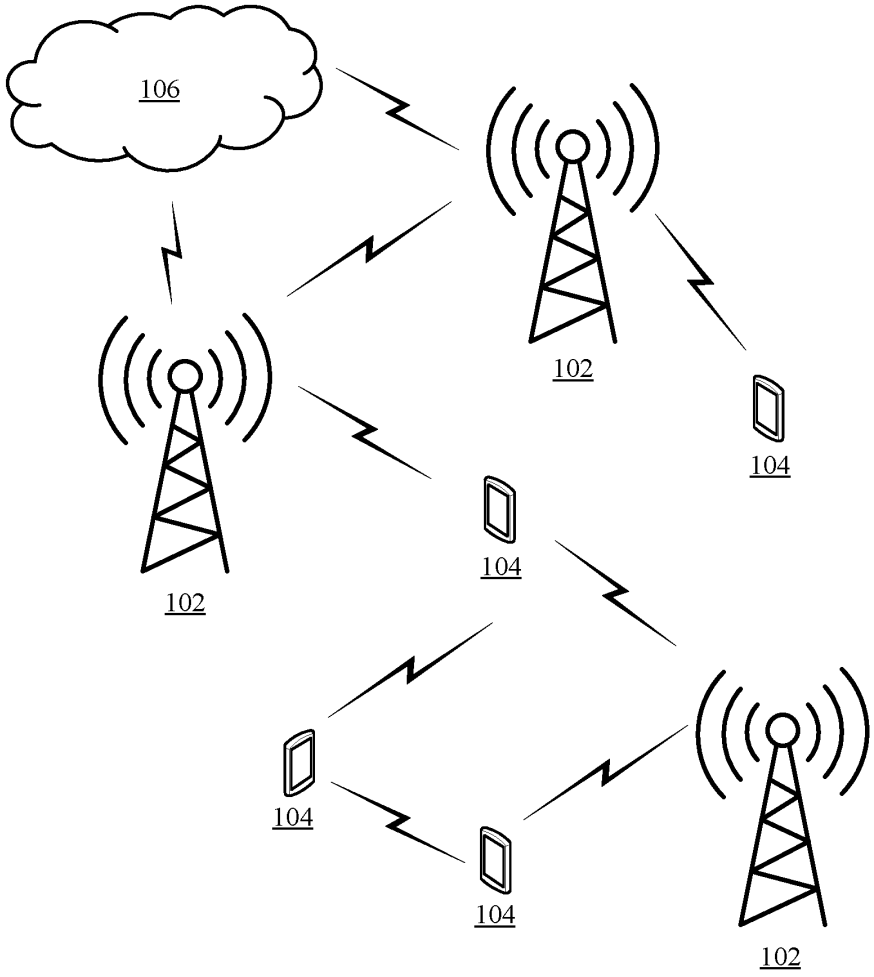


Figure 1

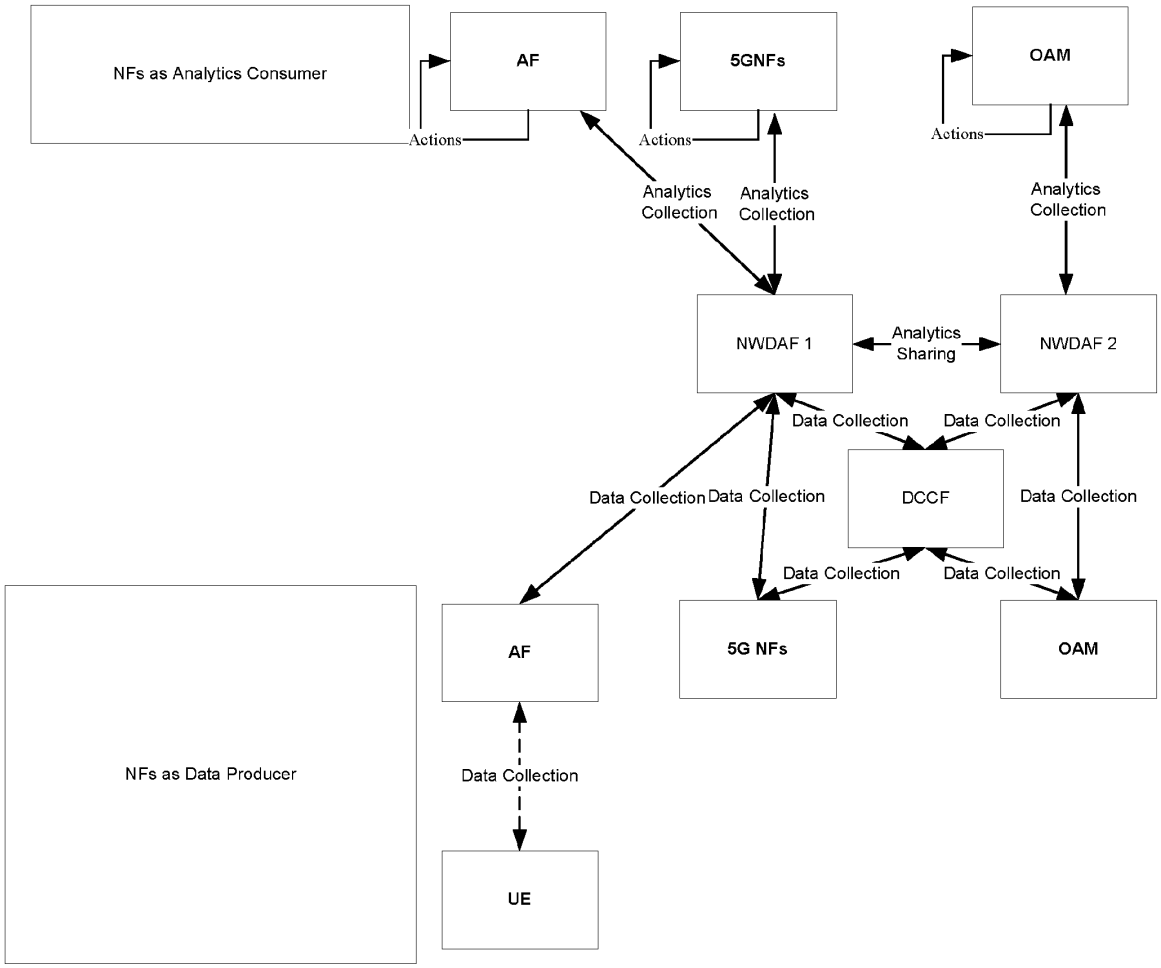

NFs as Analytics Consumer
AF
5GNFs
OAM
Actions
Actions
Actions
Analytics Collection
Analytics Collection
Analytics Collection
NWDAF 1
Analytics Sharing
NWDAF 2
Data Collection
Data Collection
Data Collection
Data Collection
DCCF
Data Collection
Data Collection
Data Collection
NFs as Data Producer
AF
5G NFs
OAM
Data Collection
UE

Figure 2

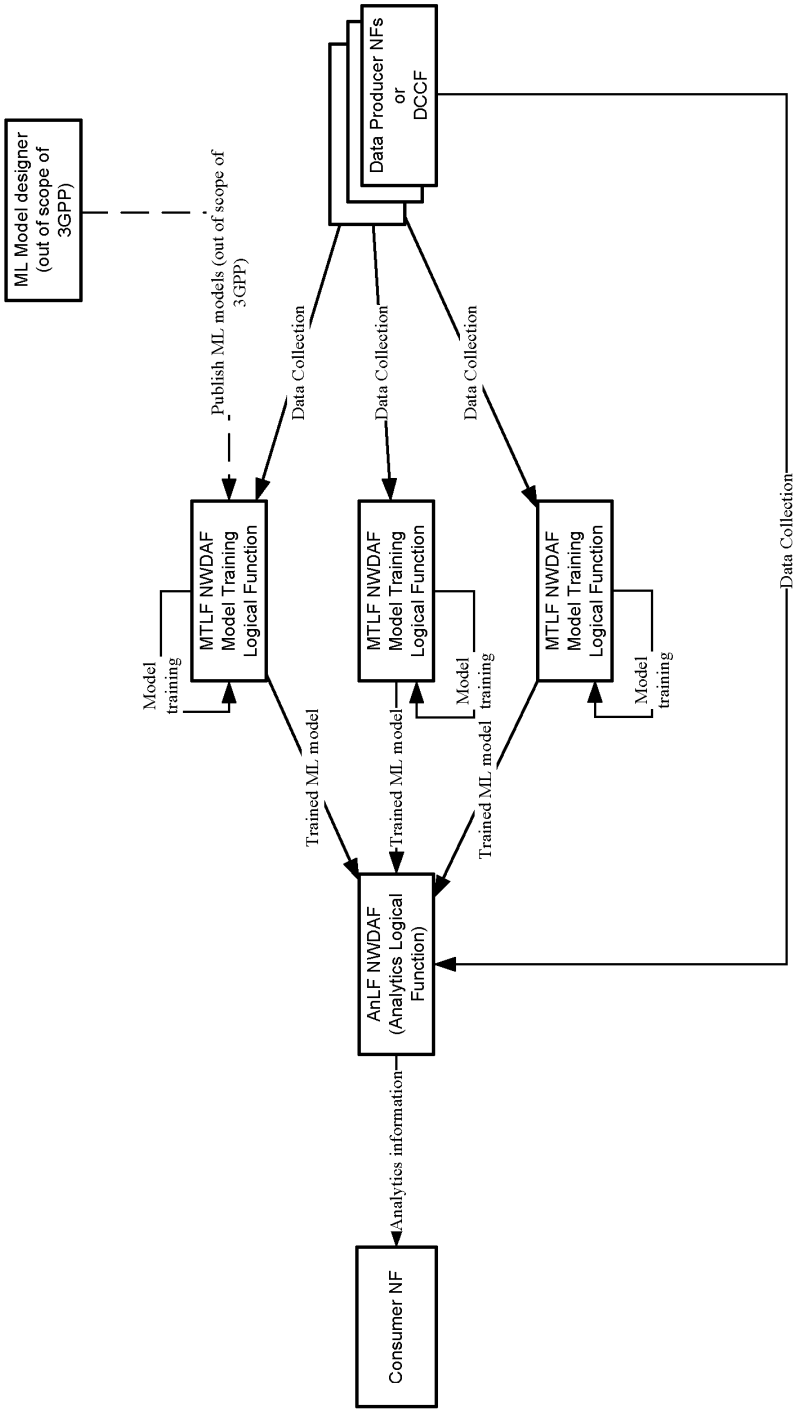

ML Model designer (out of scope of 3GPP)
Publish ML models (out of scope of 3GPP)
Data Producer NFs or DCCF
Data Collection
Data Collection
Data Collection
Data Collection
MTLF NWDAF Model Training Logical Function
MTLF NWDAF Model Training Logical Function
MTLF NWDAF Model Training Logical Function
Model training
Model training
Model training
Trained ML model
Trained ML model
Trained ML model
AnLF NWDAF (Analytics Logical Function)
Analytics information
Consumer NF

Figure 3

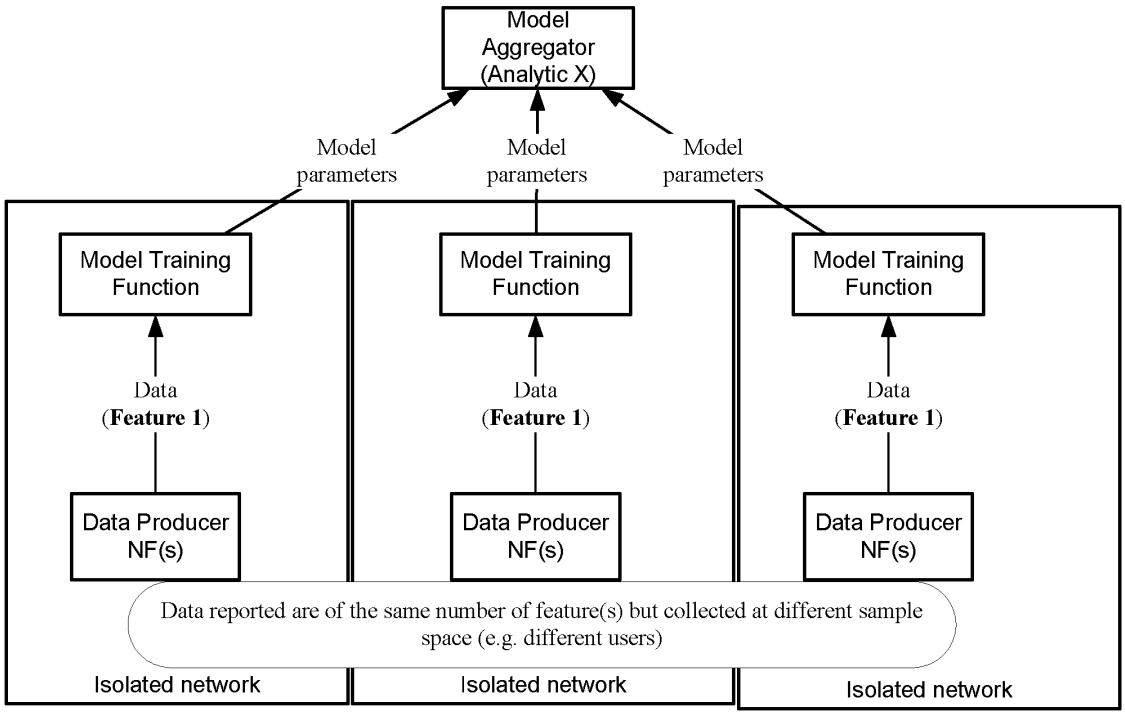


Figure 4A

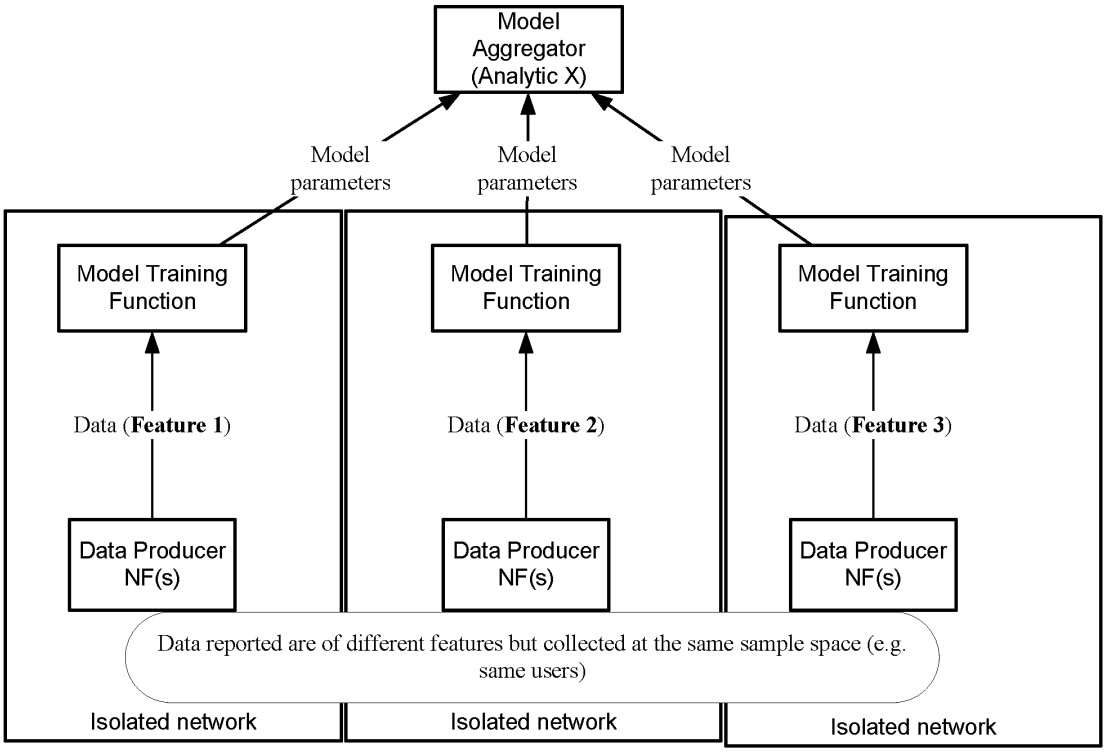


Figure 4B

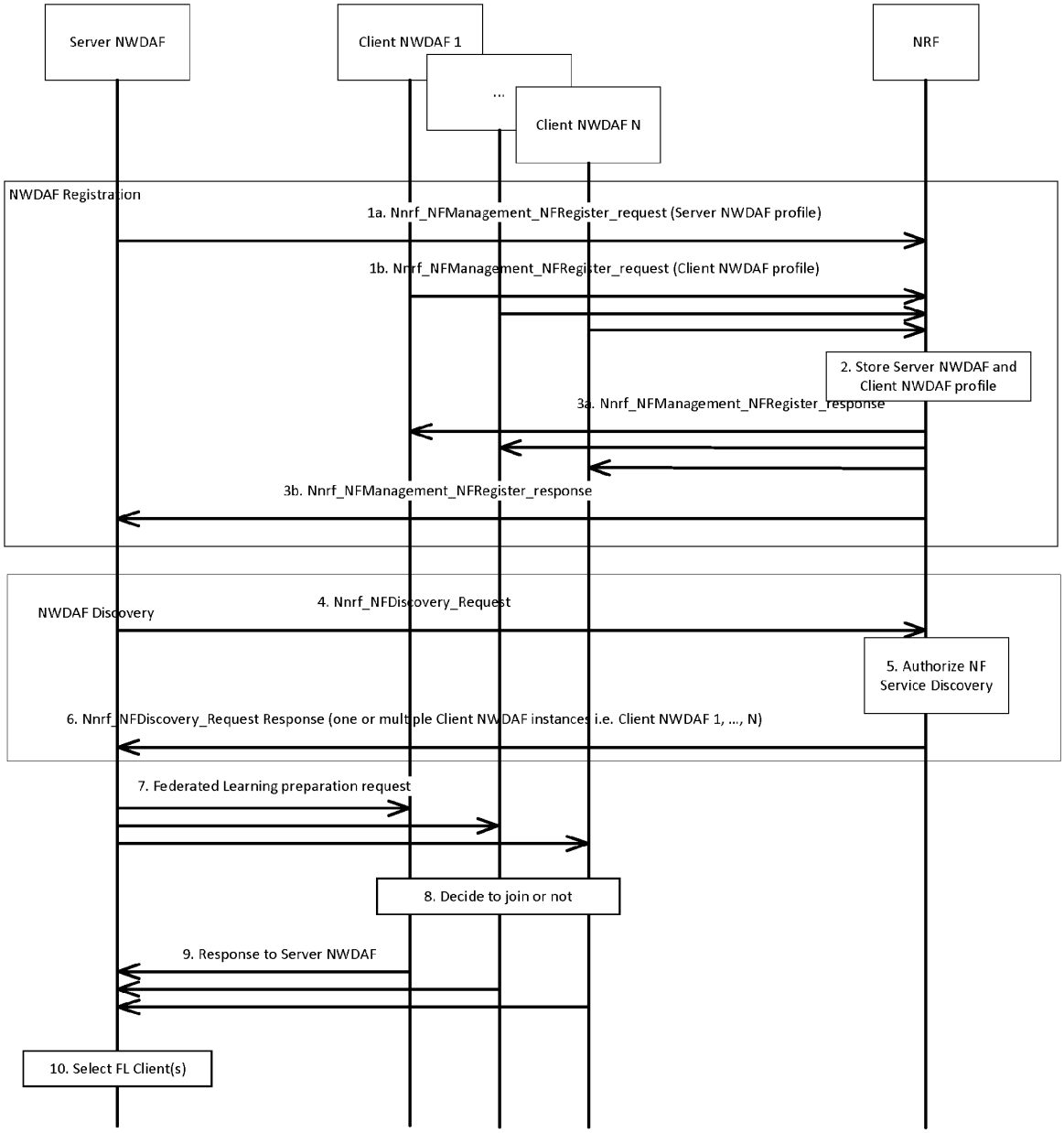

Server NWDAF
Client NWDAF 1
...
Client NWDAF N
NRF
NWDAF Registration
1a. Nnrf_NFManagement_NFRegister_request (Server NWDAF profile)
1b. Nnrf_NFManagement_NFRegister_request (Client NWDAF profile)
2. Store Server NWDAF and Client NWDAF profile
3a. Nnrf_NFManagement_NFRegister_response
3b. Nnrf_NFManagement_NFRegister_response
NWDAF Discovery
4. Nnrf_NFDiscovery_Request
5. Authorize NF Service Discovery
6. Nnrf_NFDiscovery_Request Response (one or multiple Client NWDAF instances i.e. Client NWDAF 1, ..., N)
7. Federated Learning preparation request
8. Decide to join or not
9. Response to Server NWDAF
10. Select FL Client(s)

Figure 5A

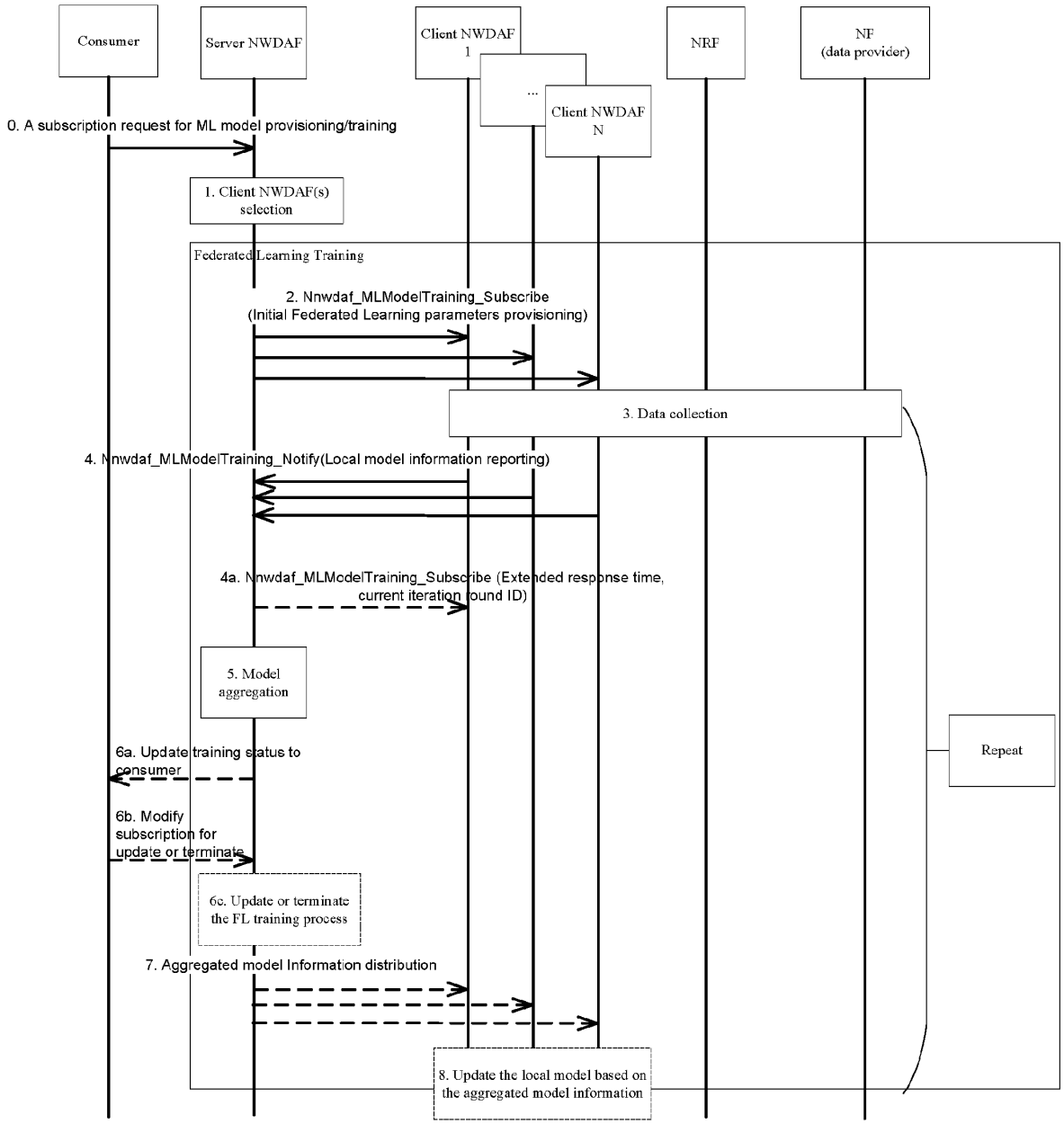

Consumer
Server NWDAF
Client NWDAF 1
...
Client NWDAF N
NRF
NF (data provider)
0. A subscription request for ML model provisioning/training
1. Client NWDAF(s) selection
Federated Learning Training
2. Nnwdaf_MLModelTraining_Subscribe (Initial Federated Learning parameters provisioning)
3. Data collection
4. Nnwdaf_MLModelTraining_Notify(Local model information reporting)
4a. Nnwdaf_MLModelTraining_Subscribe (Extended response time, current iteration round ID)
5. Model aggregation
Repeat
6a. Update training status to consumer
6b. Modify subscription for update or terminate
6c. Update or terminate the FL training process
7. Aggregated model Information distribution
8. Update the local model based on the aggregated model information

Figure 5B

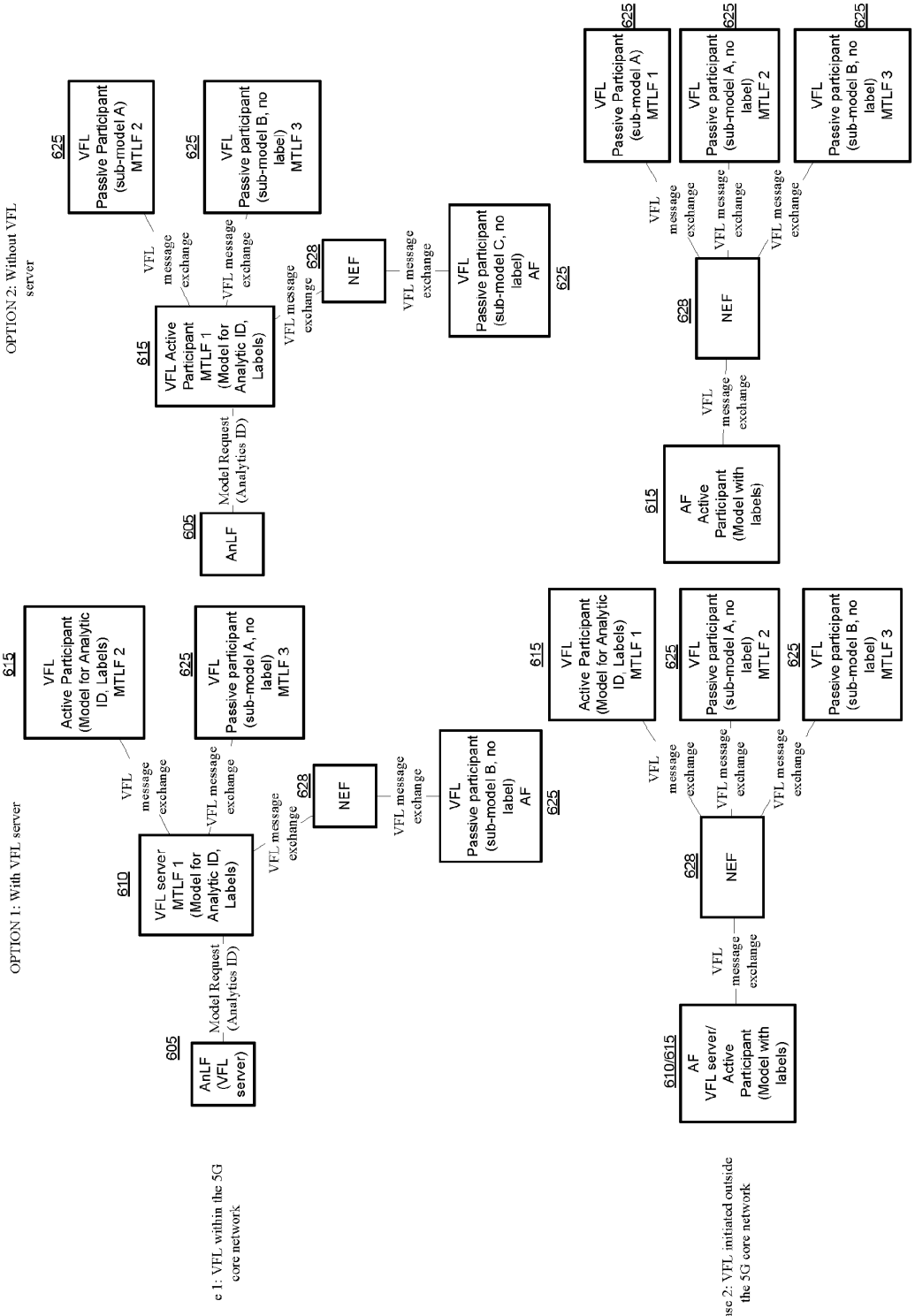
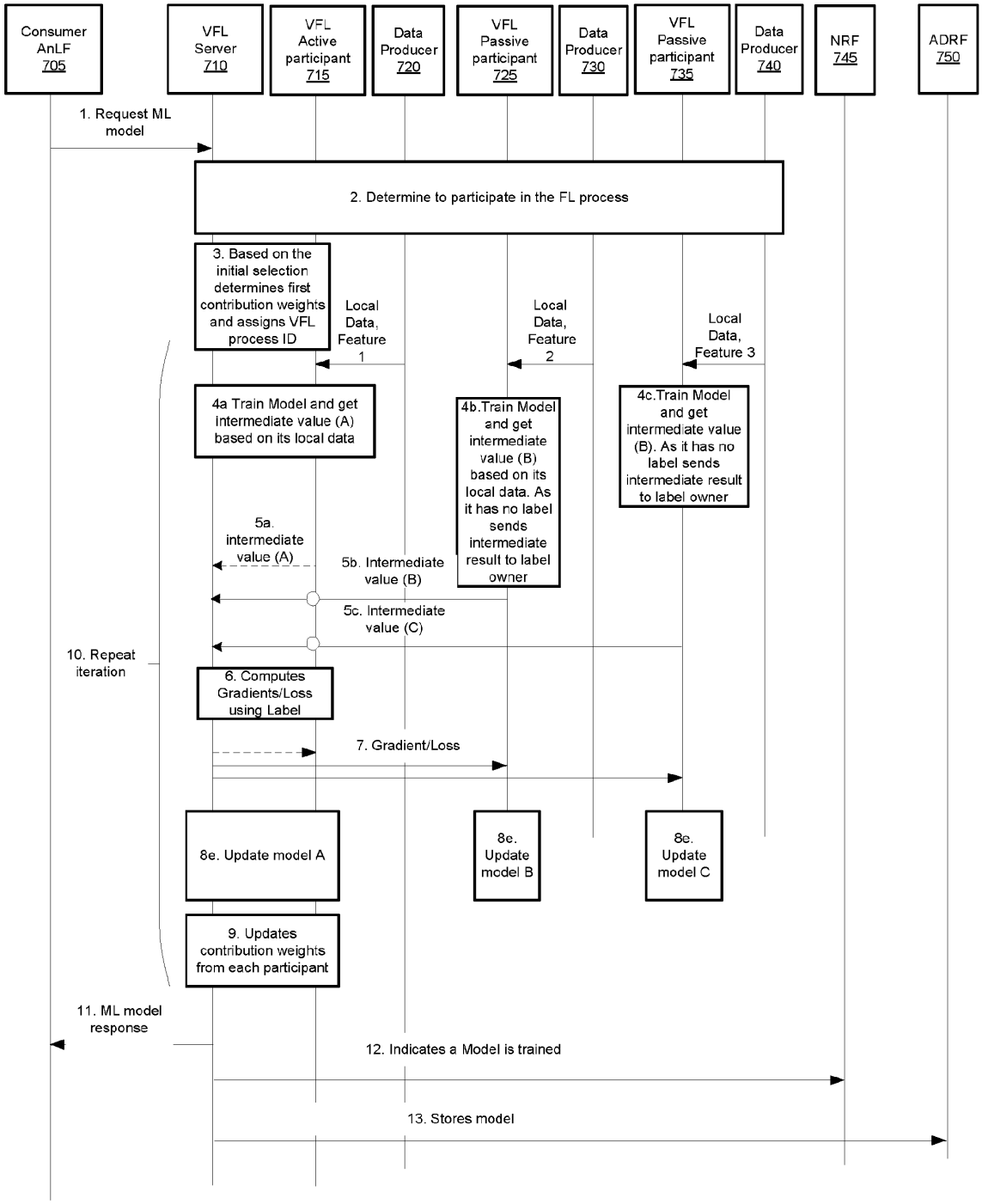

OPTION 1: With VFL server
OPTION 2: Without VFL server
Case 1: VFL within the 5G core network
Case 2: VFL initiated outside the 5G core network
AnLF (VFL server)
Model Request (Analytics ID)
VFL server MTLF 1 (Model for Analytic ID, Labels)
VFL Active Participant (Model for Analytic ID, Labels) MTLF 2
VFL Passive participant (sub-model A, no label) MTLF 3
NEF
VFL Passive participant (sub-model B, no label) AF
AnLF
VFL Active Participant MTLF 1 (Model for Analytic ID, Labels)
VFL Passive Participant (sub-model A) MTLF 2
VFL Passive participant (sub-model B, no label) MTLF 3
VFL Passive participant (sub-model C, no label) AF
AF VFL server/ Active Participant (Model with labels)
AF Active Participant (Model with labels)
VFL Active Participant (Model for Analytic ID, Labels) MTLF 1
VFL Passive participant (sub-model A, no label) MTLF 2
VFL Passive participant (sub-model B, no label) MTLF 3
VFL Passive Participant (sub-model A) MTLF 1
VFL Passive participant (sub-model A, no label) MTLF 2
VFL Passive participant (sub-model B, no label) MTLF 3
VFL message exchange
Model Request (Analytics ID)

Figure 6


Consumer AnLF 705
VFL Server 710
VFL Active participant 715
Data Producer 720
VFL Passive participant 725
Data Producer 730
VFL Passive participant 735
Data Producer 740
NRF 745
ADRF 750
1. Request ML model
2. Determine to participate in the FL process
3. Based on the initial selection determines first contribution weights and assigns VFL process ID
Local Data, Feature 1
Local Data, Feature 2
Local Data, Feature 3
4a Train Model and get Intermediate value (A) based on its local data
4b.Train Model and get intermediate value (B) based on its local data. As it has no label sends intermediate result to label owner
4c.Train Model and get intermediate value (B). As it has no label sends intermediate result to label owner
5a. intermediate value (A)
5b. Intermediate value (B)
5c. Intermediate value (C)
10. Repeat iteration
6. Computes Gradients/Loss using Label
7. Gradient/Loss
8e. Update model A
8e. Update model B
8e. Update model C
9. Updates contribution weights from each participant
11. ML model response
12. Indicates a Model is trained
13. Stores model

igure 7

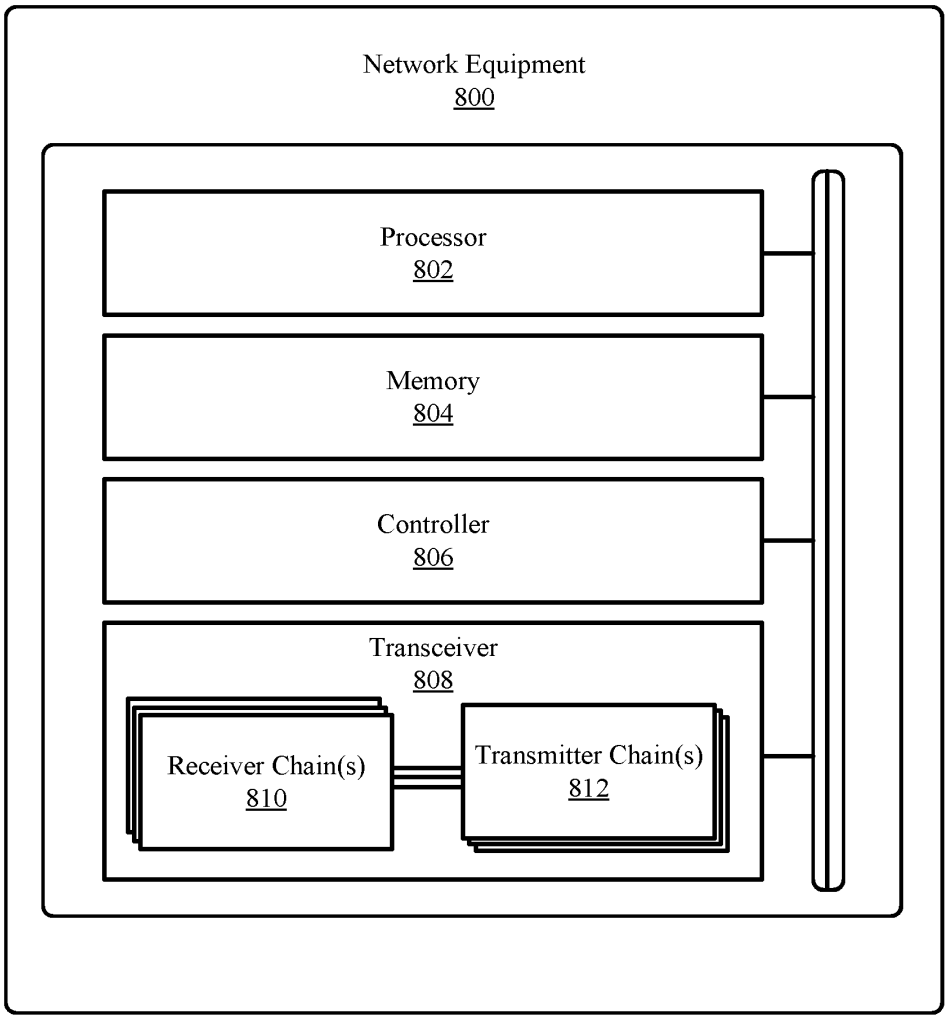

Network Equipment
800
Processor
802
Memory
804
Controller
806
Transceiver
808
Receiver Chain(s)
810
Transmitter Chain(s)
812

Figure 8

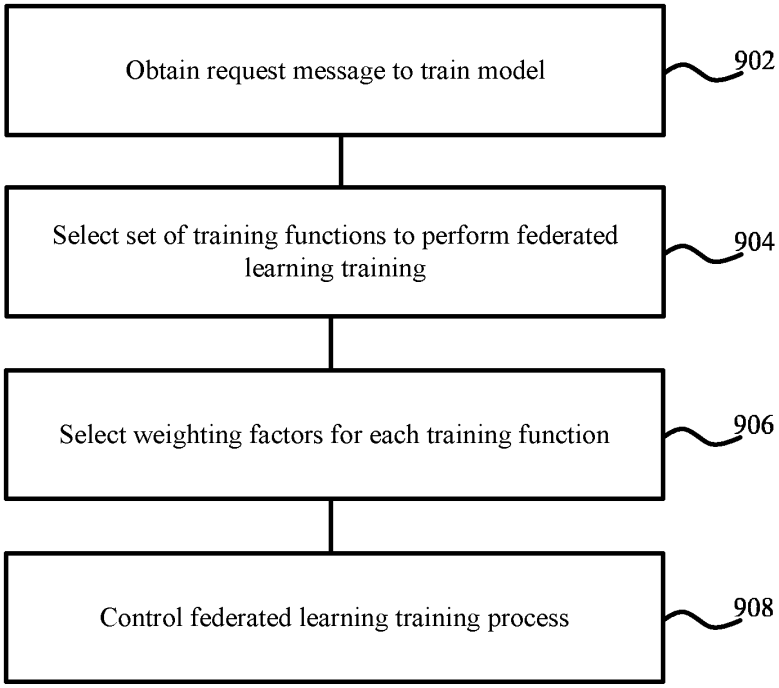

Obtain request message to train model
902
Select set of training functions to perform federated learning training
904
Select weighting factors for each training function
906
Control federated learning training process
908

Figure 9