OpenKasugai Controller (Extensions)

v1.0.0

Term definitions (1)

Terminology	Description
Function Chain	Definition of the features that make up the data processing flow and the connectivity relationships between the features. May be provided as a template.
Function	It is a function defined in a function chain, specifically a data processing module.
Data Flow	It deploys a function chain to a physical resource, and what it deploys.
User	Users of this system. There are three types of users. (1) DF execution administrator (who requests DF deployment + who manages apps that receive input into DF and output from DF). (2) Operator of this system (who provides DF to DF execution administrator). (3) Developers (someone who develop features (such as functions) required by DF).
GW	Entry and exits visible to DF execution administrator. (Images like Kafka, RabbitMQ, and NetScaler. It could be a GW service in the cloud.)
StartPoint (SP), EndPoint(EP)	The source and destination of the data flow. Currently, it is a camera and distribution server. In the future, it will be expanded to include functions such as entry GW and exit GW, such as session trimming.
Toggle	Data frow replacement process.
Scheduling Condition	When deploying a data flow, specifications regarding the deployment destination (for example, direct specification of deployment nodes/devices or removal from candidates, and filter execution strategy) are made. By selecting predefined scheduling conditions at the time of data flow deployment request, the deployment destination is determined according to those conditions.
Filter Execution Strategy	Specifying the filter to apply during scheduling. (List of filters to be applied, their order, and how many of the top deployment destination candidates that pass the filter are to be used.)

Term definitions (2)

Terminology	Description
Parent bs (parent bitstream)	The basic circuit of an FPGA. Can be used only after writing the next children bs.
Child bs (parent bitstream)	Circuit of the actual FPGA to be written on top of the parent bs .(for example, resize circuit)
Child bs Write	General term for the next three patterns of writing children bs.
Automatic Writing	Child bs If an unwritten FPGA is selected for deployment, dynamically write child bs before deploying DF function.
Manual Write	To write a child bs to an FPGA in a child bs unwritten state and make the controller recognize it as a new deployment destination candidate without stopping the controller during operation.
Overwrite	Child bs Writing child bs to a written FPGA.
Reset	Generic term for the next two patterns of FPGA resets.
Reset FPGA	Child bs returning to an unwritten FPGA.
Reset Child bs	Restore the currently written child bs to its initial state immediately after writing. Initialize the connection information set during DF deployment.
Freeing FPGA Resources	To release resources of an FPGA consumed by DF deployment and return them to an unused state. This is an FPGA-side operation that has nothing to do with K8s resources or controllers.
Branch	A generic term for the next two patterns of branching. However, in some contexts, "Copy Branch" is abbreviated
Copy Branch	Copy one data to multiple destinations.
Conditional Branch	Send a piece of data to a specific destination.
Integration	Flow multiple processing results into one.
Glue	A function that converts the connection type of a function that has different input/output connection types (for example, TCP→DMA) By deploying between functions with different connection types, you can deploy an DF that connects these functions (which cannot be connected).

Contents

1. Introduction
   - Value Proposition
   - Extensions List

2. DF branching into multiple functions
   - Copy Branch Processing Module
   - OpenKasugai Controller Enhancements

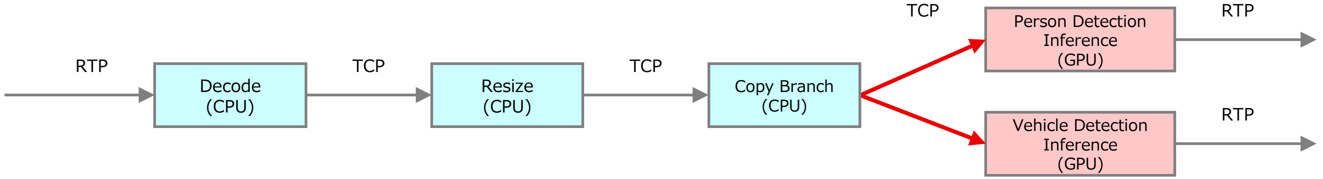
3. DF connecting functions of different connection types
   - Glue Processing Module
   - OpenKasugai Controller Enhancements

1. Introduction

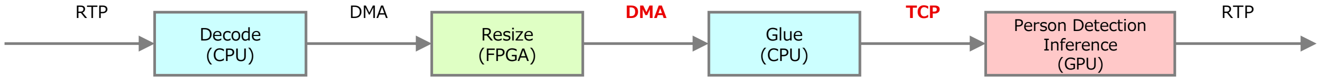
Value proposition

- Increase the variations of deployable DFs to enable the deployment of diverse data flows.
  - A copy branch processing module can be used to deploy data flows that branch into multiple functions along the way.
  - A connection type conversion module (Glue processing module) can be used to deploy data flows that connect functions with different connection types.

DF that branches into multiple functions


RTP
Decode (CPU)
TCP
Resize (CPU)
TCP
Copy Branch (CPU)
TCP
Person Detection Inference (GPU)
RTP
Vehicle Detection Inference (GPU)
RTP

DF connected between functions with different connection types



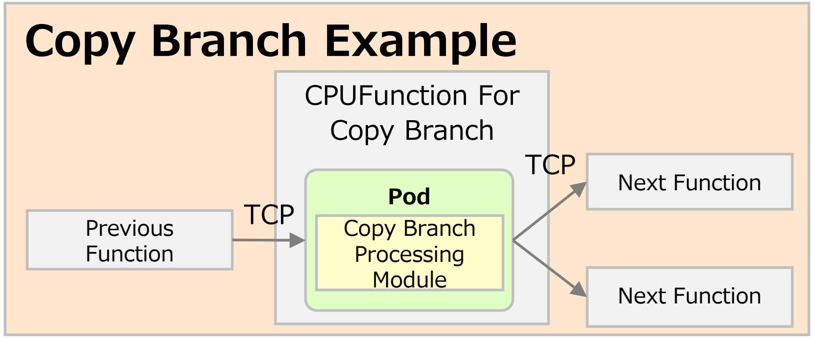
Extensions list

DF that can be built	Overview of Extensions
DF that branches into multiple functions	• Provide a copy branch processing module as a function. • Extend the controller to manage functions with multiple inputs and outputs. • Extend the controller to Define a DF with Branches.
DF connected between functions with different connection types	• Provide a Glue processing module as a function. • Extending the controller to manage functions with different input/output connection types.

2. DF that branches into multiple functions

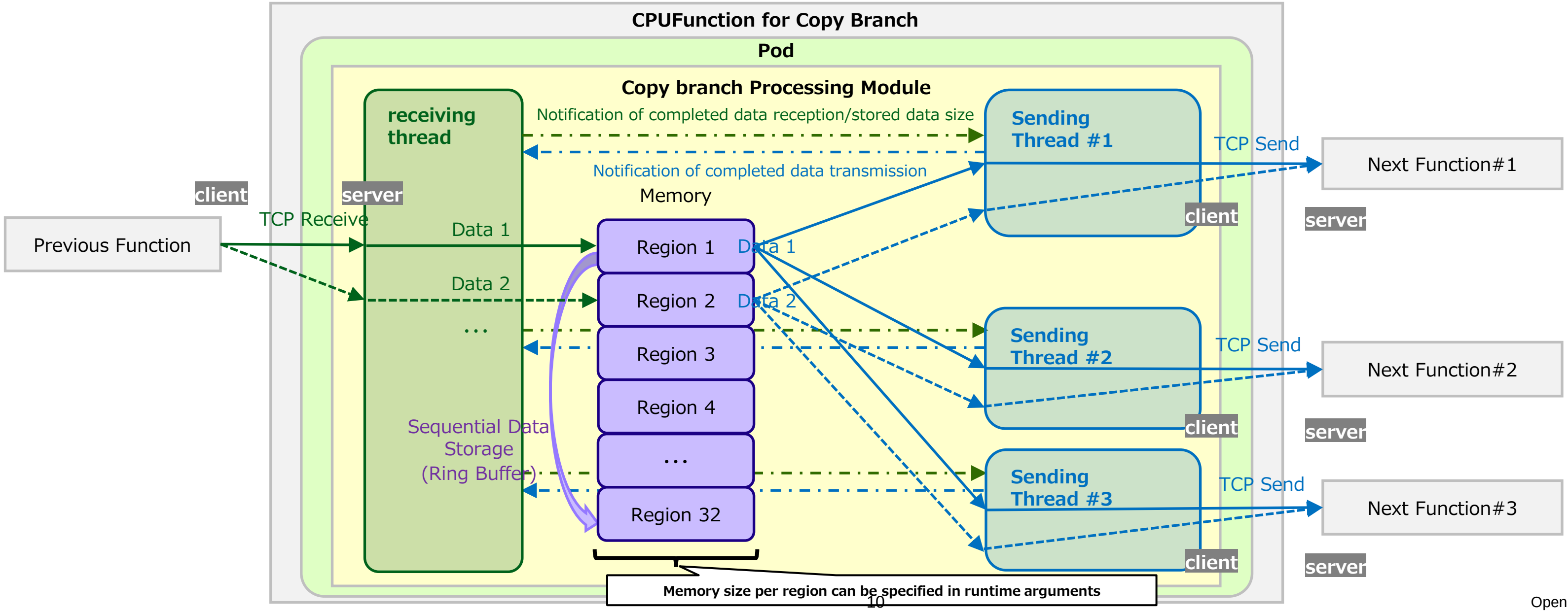
Copy branch processing module: Summary

- Processing for distributing and outputting input from a previous function to multiple next functions.
  - TCP input/TCP output
  - The number of branches can be set to any number.



Copy branch processing module : Block diagram

- The copy branch processing module consists of one receiving thread and sending threads corresponding to the number of branches.
  - The receiving/sending thread communicates using completion notifications prepared for each sending thread and each memory area.
  - When receiving data from the previous function and storing it in memory is completed, the receiving thread notifies the stored data size and the reception completion.
  - If data reception is completed, the sending thread transmits data corresponding to the stored data to the next function, and then notifies the transmission completion.



OpenKasugai controller enhancements: Managing functions with multiple inputs and outputs

- Extend the CR in the app catalog to manage the number of input and output ports for functions.
  - The maximum number of ports for input/output is described, and the DF definition determines the number of ports actually used.
  - Check the DF definition to ensure that the number of ports for each function in the DF definition does not exceed the maximum number of ports listed in the catalog.
  - Note)The "port" of a function is a cataloged concept,
    different from the "NIC" of a pod, etc.

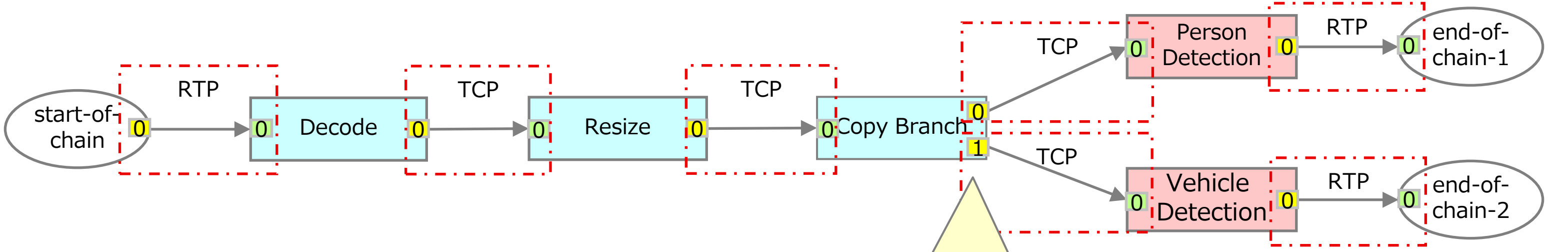
Catalog Example

```
apiVersion: v1
kind: ConfigMap
metadata:
  name: funcinfo-copy-branch
  namespace: wbfunc-imgproc
data:
  deployableItems: '[
    {
      "name": "item1",
      "regionType": "cpu",
      "inputInterfaceType": "host100gether",
      "outputInterfaceType": "host100gether",
      "configName": "cpufunc-config-copy-branch",
      "specName": "spec1"
    }
  ]'
  spec: '[
    {
      "name": "spec1",
      "minCore": 1,
      "maxCore": 1,
      "maxDataFlowsBase": 1,
      "maxCapacityBase": 15,
      "maxInputNum": 1,
      "maxOutputNum":10
    }
  ]'
```

Describe the maximum number of connections

OpenKasugai controller enhancements: Defining DF with branches

- Extend the data flow CR to represent a DF with multiple branching functions.
  - When branching, which port is connected is managed by number (number in square).
  - Multiple DF start and end points are also managed. (start-of-chain, end-of-chain-1,2)



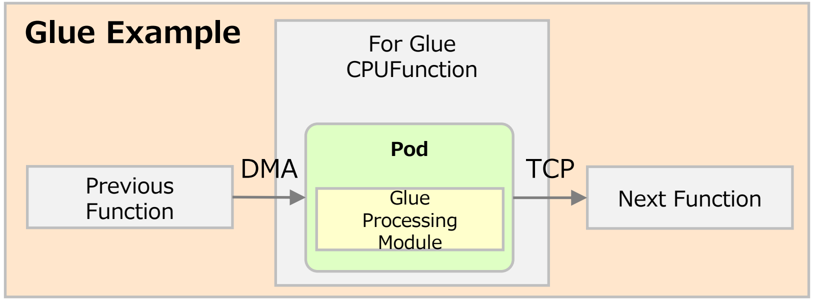
The person detection function is connected to the 0 output port of the copy branch function.

The vehicle detection function is connected to the 1 output port of the copy branch function.

3. DF connected between functions with different connection types

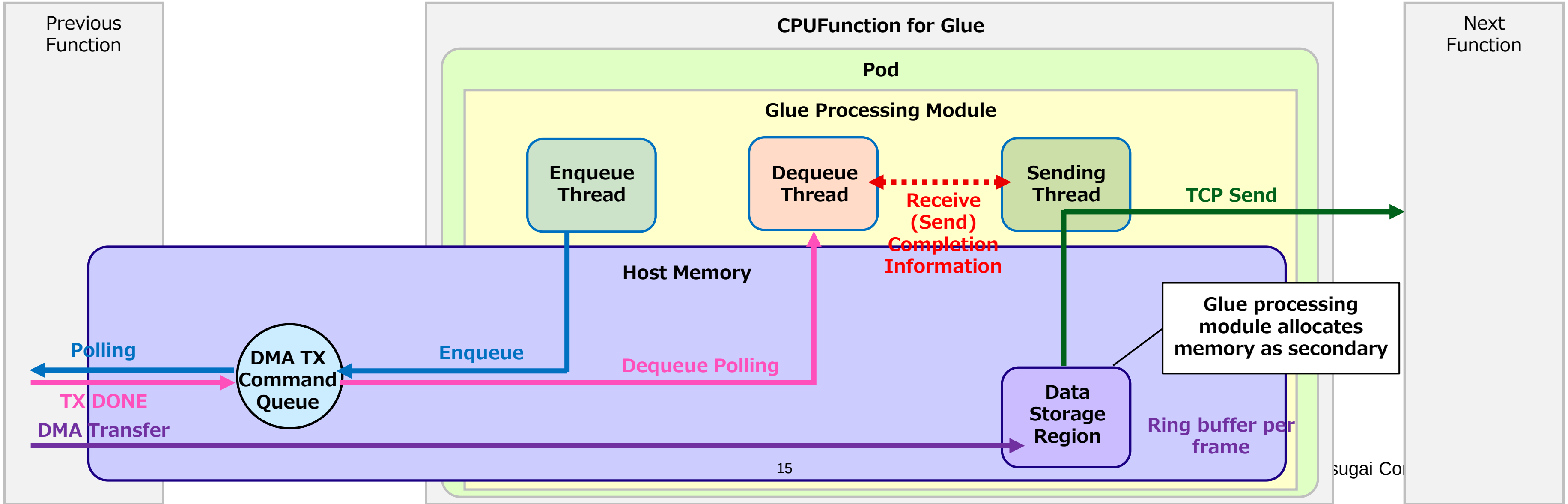
Glue processing module: Summary

- Process of connecting data transfers between different connection types.
  - DMA input/TCP output



Glue processing module: Block diagram

- The Glue processing module consists of an enqueue thread, a dequeue thread, and a send thread.
  - Make TX DMA requests to the DMA TX command queue on the enqueue thread and poll on the dequeue thread.
  - When the dequeue thread detects the completion DMA transfer of the previous function, it notifies the sending thread that it has completed receiving.
  - When the sending thread receives a completion notification, it sends the data to the next function via TCP and then notifies the dequeue thread of the completion.



OpenKasugai controller enhancements:
Managing functions with different Input/Output connection types

- Extending the CR of the app catalog to manage the connection type of the function input port and output port
  - As a check of DF definitions, check whether the connection type of each connection in the DF definition matches the connection types listed in the catalogs of the functions at both ends.

Catalog Example

```
apiVersion: v1
kind: ConfigMap
metadata:
  name: funcinfo-glue-fdma-to-tcp
  namespace: wbfunc-imgproc
data:
  deployableItems: '[
    {
      "name": "item1",
      "regionType": "cpu",
      "inputInterfaceType": "mem",
      "outputInterfaceType": "host100gether",
      "configName": "cpufunc-config-glue-fdma-to-tcp",
      "specName": "spec1"
    }
  ]'
  spec: '[
    {
      "name": "spec1",
      "minCore": 1,
      "maxCore": 1,
      "maxDataFlowsBase": 1,
      "maxCapacityBase": 15,
      "maxInputNum": 1,
      "maxOutputNum":1
    }
  ]'
```

Indicates the input/output connection type.