# SICE 2011
# RT-Middleware Tutorial

Date : 2011/9/13　10:00～16:30
Place : SICE 2011

# RT-Middleware tutorial

| | |
|---|---|
| 10:00 - 10:45 | **Part 1: Introducing RT-Middleware** |
| | Tetsuo Kotoku (AIST) |
| | An introduction to RT-Middleware, RT-Systems and RT-Components. |
| 11:00 - 12:30 | **Part 2: Building RT-Systems using RT-Middleware** |
| | Geoffrey Biggs (AIST) |
| | Hands-on practice using small samples to construct complete RT-Systems. |
| 13:30 - 15:00 | **Part 3: Creating RT-Components** |
| | Geoffrey Biggs (AIST) |
| | Hands-on practice creating RT-Components. |
| 15:15 - 16:00 | **Part 4: Human interaction with OpenHRI** |
| | Yosuke Matsusaka (AIST) |
| | A demonstration of RT-Components for human-robot interaction. |
| 16:00 - 16:30 | **Part 5: Discussion** |
| | |
| | |

# Part 3: Creating RT-Components

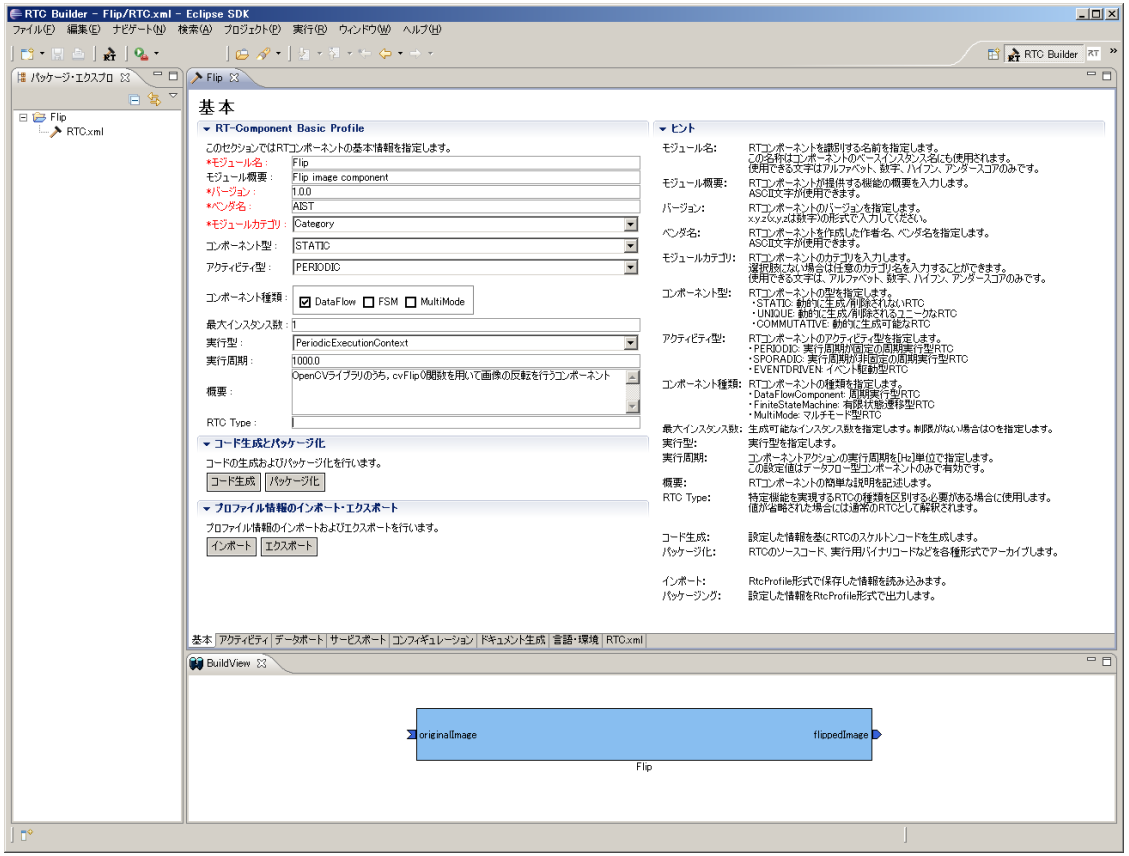
Geoffrey Biggs (AIST)

# RTCBuilder

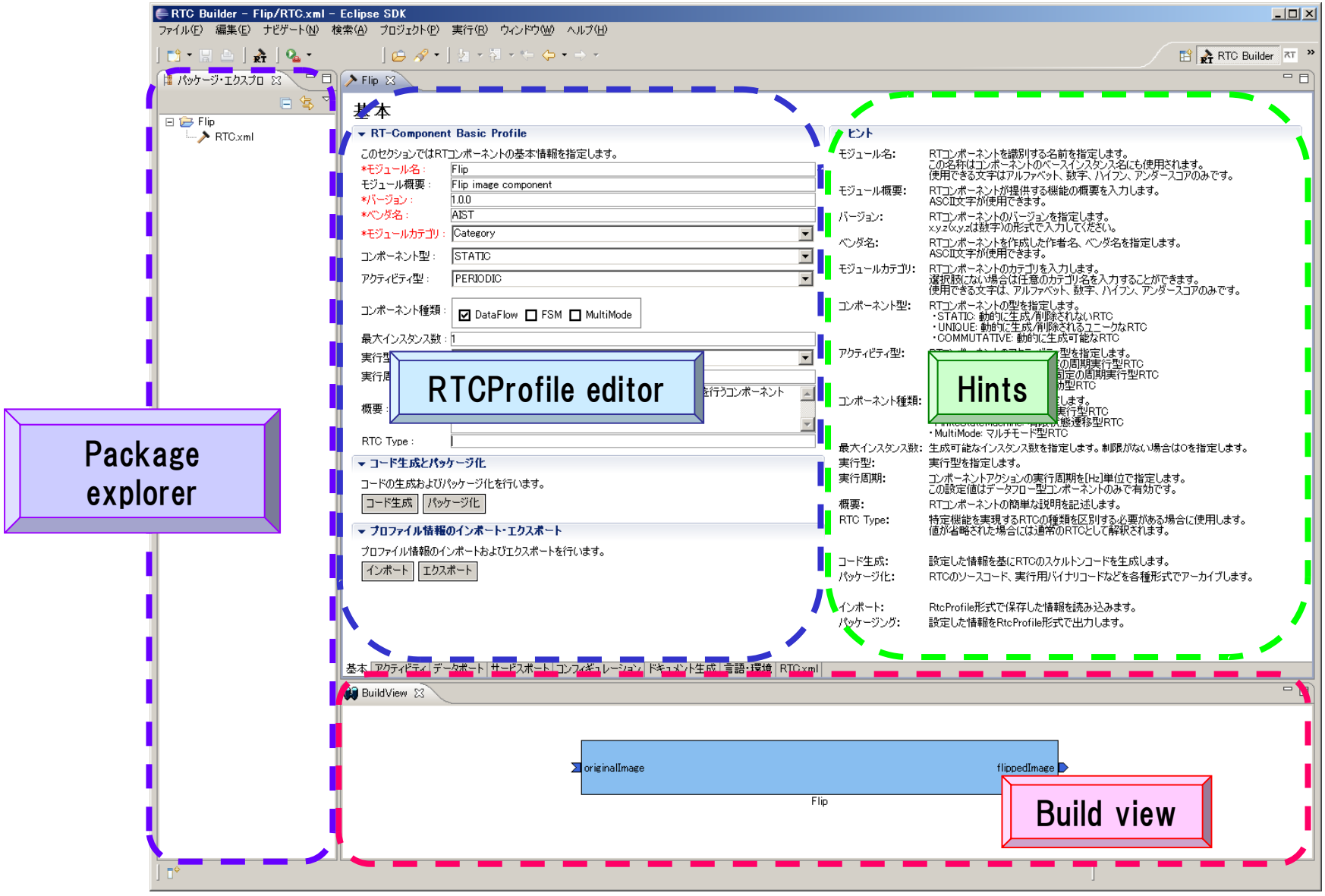
# RTCBuilder outline

- What is RTCBuilder?
  - A tool for specifying a component profile and generating template source code.
  - Support for generating templates in new languages can be added via plugins.
    - C++
    - Java
    - Python

※C ++ code generation is included by default.
※Other languages are offered as plugins.



# Screen layout



# Download the sample component

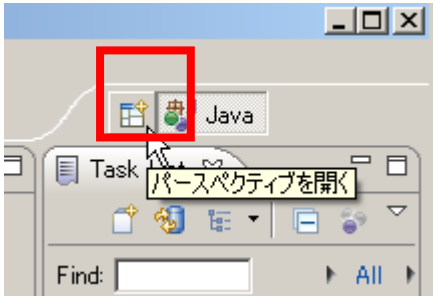
- Download USBCamera.zip from this URL
  http://www.openrtm.org/openrtm/en/content/sice-2011-openrtm-aist-tutorial

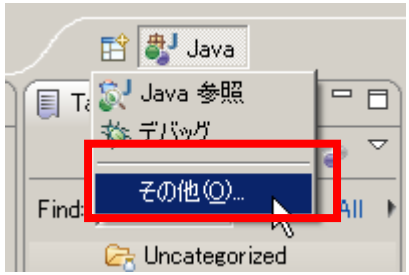
- Extract the archive.
  ※ If extracted to a path with spaces in it, errors will occur when building with VC++.

# Preparation

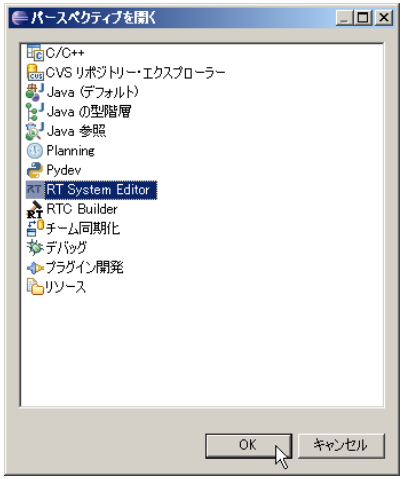
- Change the perspective

① Click the “Change perspective” button in the top right, and select “Other”



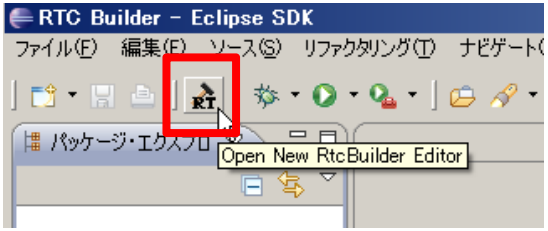

②Select “RTCBuilder”




※Perspective
A tool in Eclipse.
Changes the menus, toolbars, editors, views, etc. to match the perspective’s goals.

# Project creation and starting the editor

①Click the editor's button in the toolbar

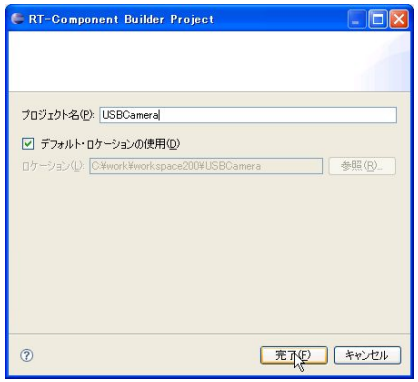



※From the File menu create a new project. In the New Project screen, select "Other" - "RTCBuilder" and click "Next"
※From the File menu, select "Open New Builder Editor"

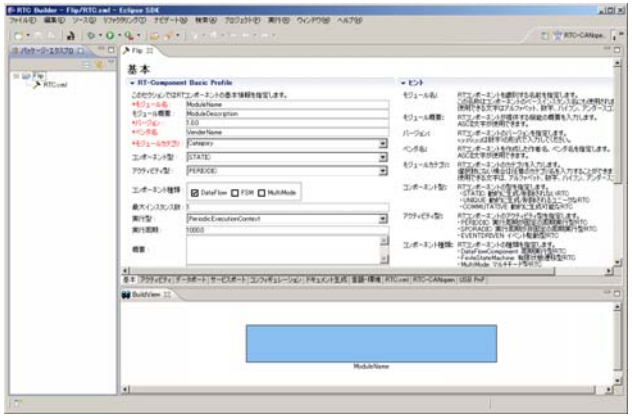
※To specify the project location, in step ②, uncheck the "Default location" checkbox and enter a path. This may be outside your workspace, but it will be treated as if it is inside the workspace.

**Project name: USBCamera**

②Enter a project name

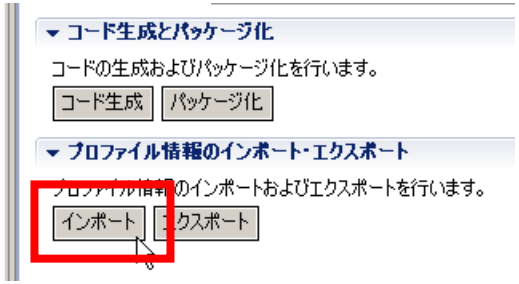



③The project is generated.

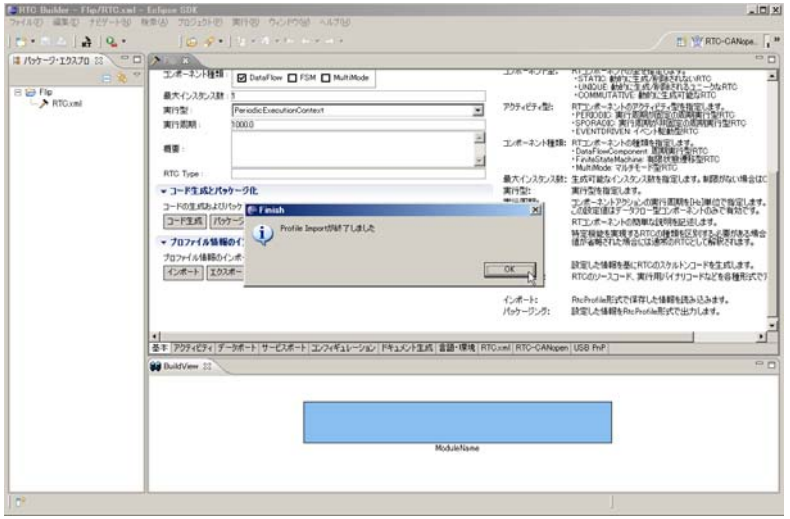



# Import the profile

①Click “Import” in the “Basic” tab



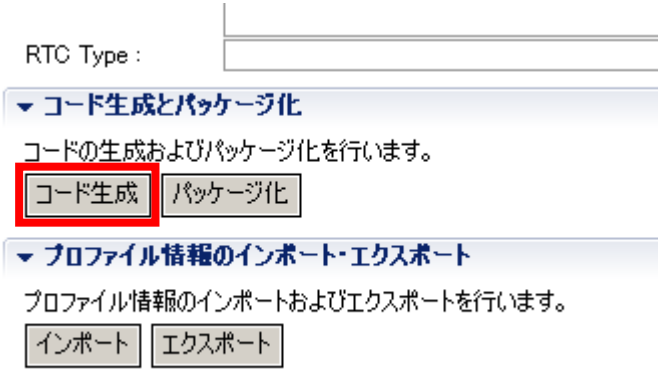

②Select the XML file.



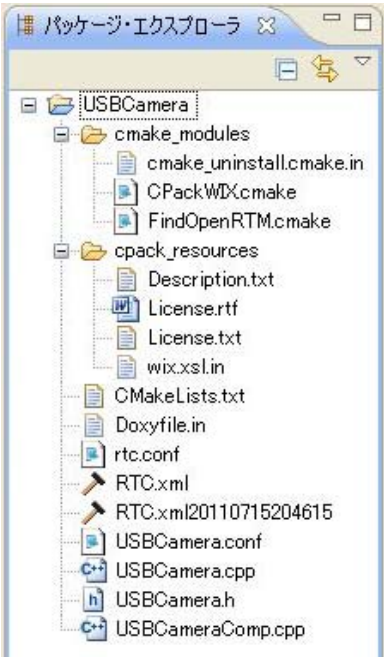
- Reusing existing RTCProfiles.
  - Existing RTCProfiles can be exported and imported.
  - Imported RTCProfiles can be used to generate code.
  - Files can be imported and exported in XML and YAML formats.

# Code generation

- Generate the code template

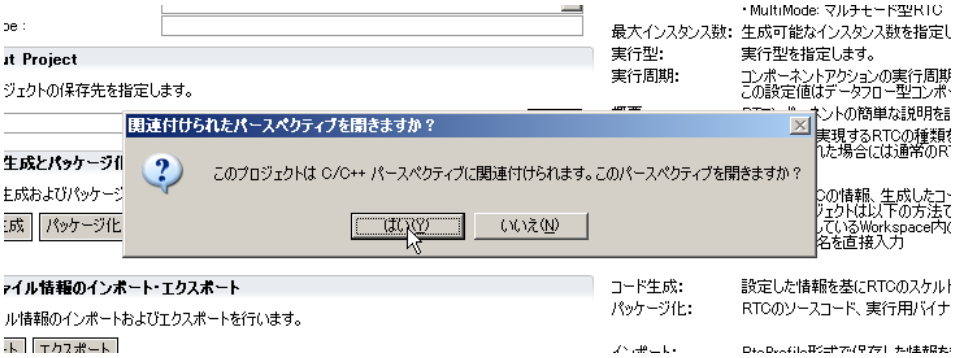







※If the code is not displayed, click “Refresh.”

- The perspective changes after generation.




C++ RTC → CDT

Java RTC → JDT

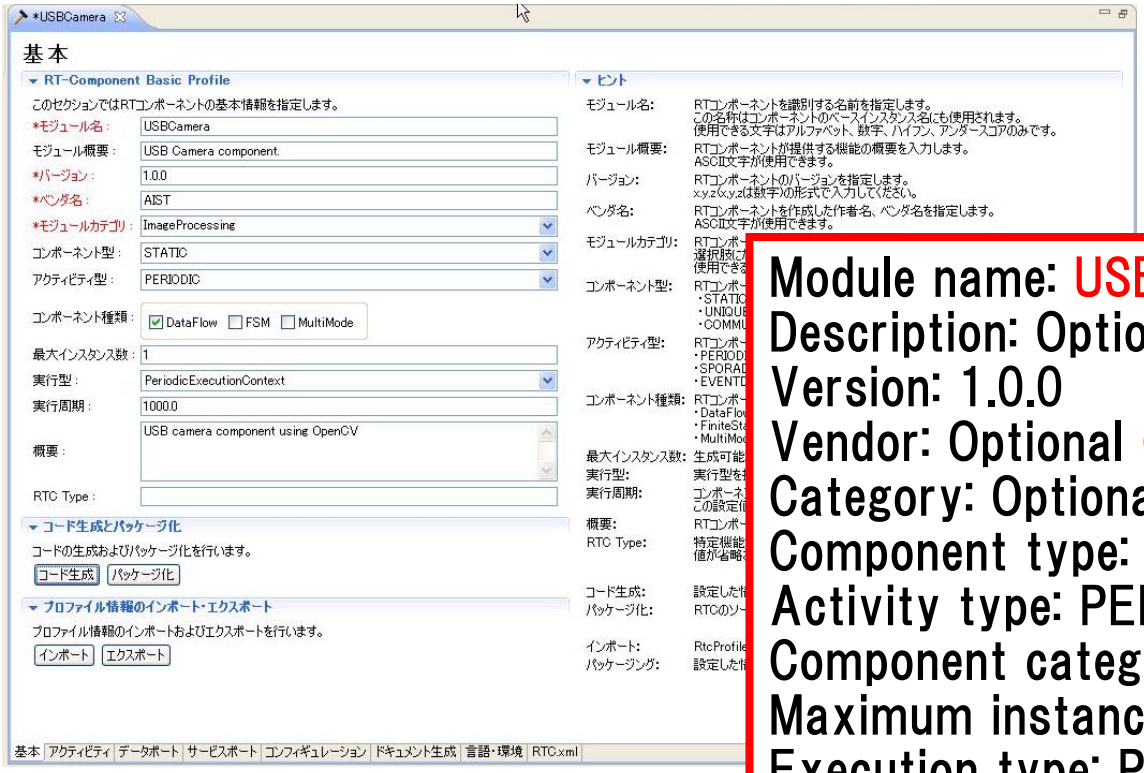
Python RTC → PyDev

# RTC Profile Editor

| Tab | Explanation |
|---|---|
| Basic profile | Enter the RTC's basic profile and information. Generate code, import/export profiles and manage packaging. |
| Activity profile | Select the activities the RTC will support. |
| Data port profile | Manage the RTC's data ports. |
| Service port profile | Manage the RTC's service ports and the service interfaces they support. |
| Configuration | Manage the configuration parameters and sets that can be edited by the RTC's users, and system configuration parameters. |
| Documentation | Edit the documentation to add to the generated code. |
| Language, environment | Select the language to generate, set the environment. |
| RTC.xml | Displays the current RTCProfile in XML format. |

# Basic profile

- RTコンポーネントの名称など，基本的な情報を設定

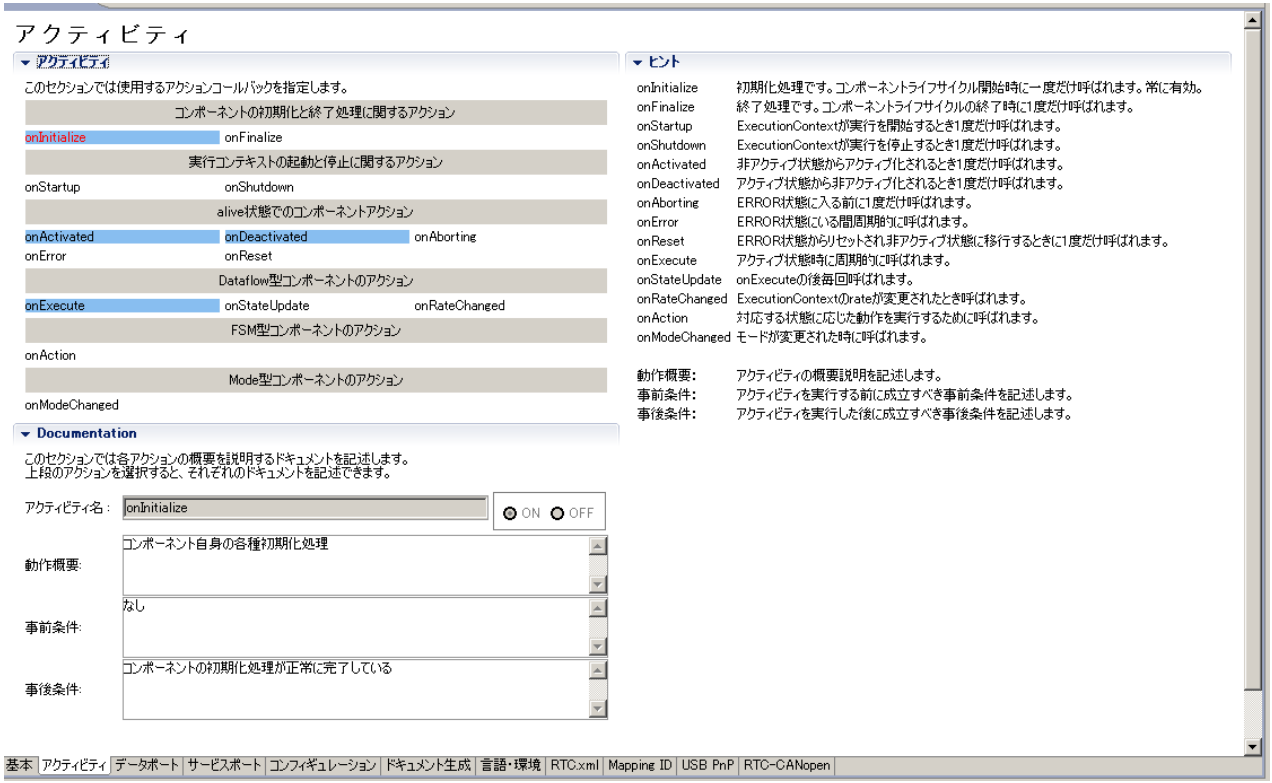



Module name: USBCamera
Description: Optional (USB Camera component)
Version: 1.0.0
Vendor: Optional (AIST)
Category: Optional (ImageProcessing)
Component type: STATIC
Activity type: PERIODIC
Component category: DataFlow
Maximum instances: 1
Execution type: PeriodicExecutionContext
Execution rate: 1000.0

※Values in red must be provided.
※Explanations are given on the right.

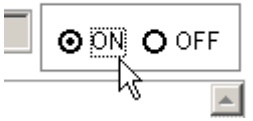
# Activity profile

- The activities to be implemented in the RTC.




①Select the activity to edit.


②Turn it on or off.



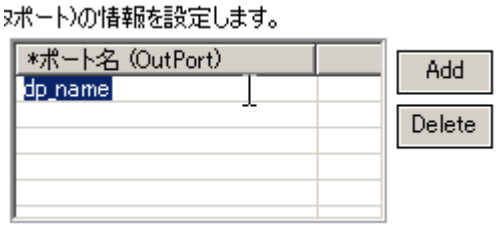

Check the following:
- onActivated
- onDeactivated
- onExecute

※The currently-selected activity is displayed in red.
※Enabled activities are highlighted in blue.
※All activities may have execution, pre- and post-condition documentation attached.

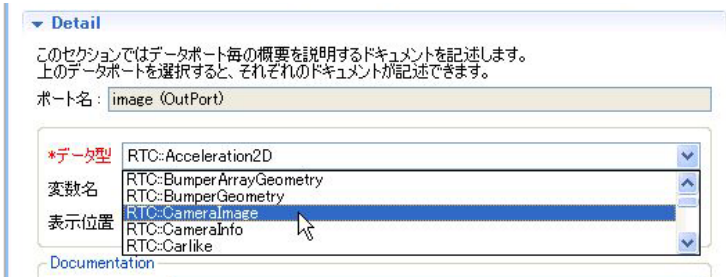
# Data port profile

- Data ports to add to the RTC.


①Select “Add” next to the type of port to add.




②Select the port’s properties.




※The available data types are specified in IDL files, which must be set in the settings screen.

※The data types provided with OpenRTM-aist (in RTM_Root]rtm/idl) can be used by default.

※Documentation can be added to the ports.

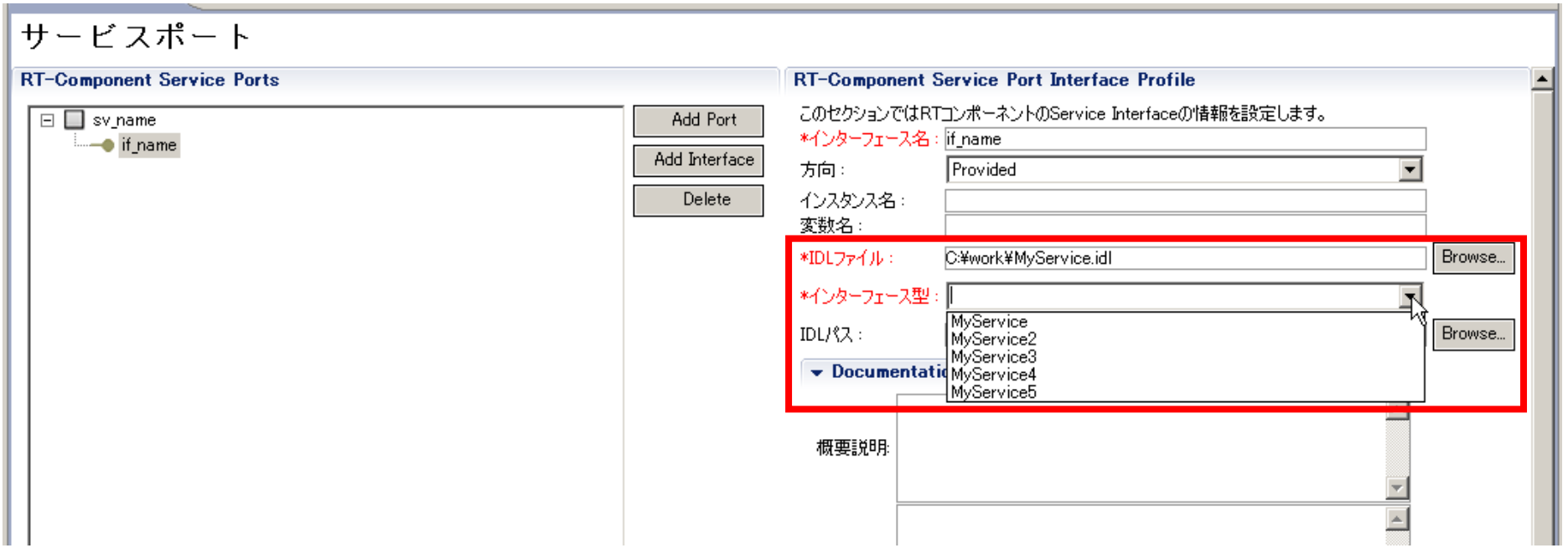
# Data port profile

※Port information is displayed in the build view.


● OutPort
Port name: image
Data type: RTC::CameraImage
Variable name: image
Display position: right

# Service port profile

- Service ports to add to the RTC.



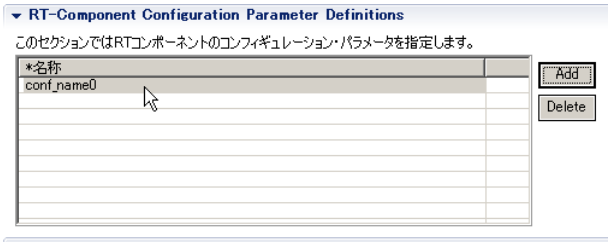

- Service port interface settings
  - Specifying an IDL file displays the interfaces in that file.

This sample does not have any service ports.

# Configuration profile

- Manage the configuration parameters of the RTC.


①Click the “Add” button and enter the parameter information.




②Enter the variable name, etc.

Name: deviceNumber
Data type: int
Default value: 0
Variable: deviceNumber
Constraints:
Widget: text

※Available data types include short, int, long, float, double, and string. Direct entry is also possible.

※Constraints and widget information are used by RTSystemEditor.

# Setting constraints and widgets

- About constraints
  - Can be set on data ports and configuration parameters
  - Checking must be performed by the developer.
    - Constraints do not mean the middleware enforces them.

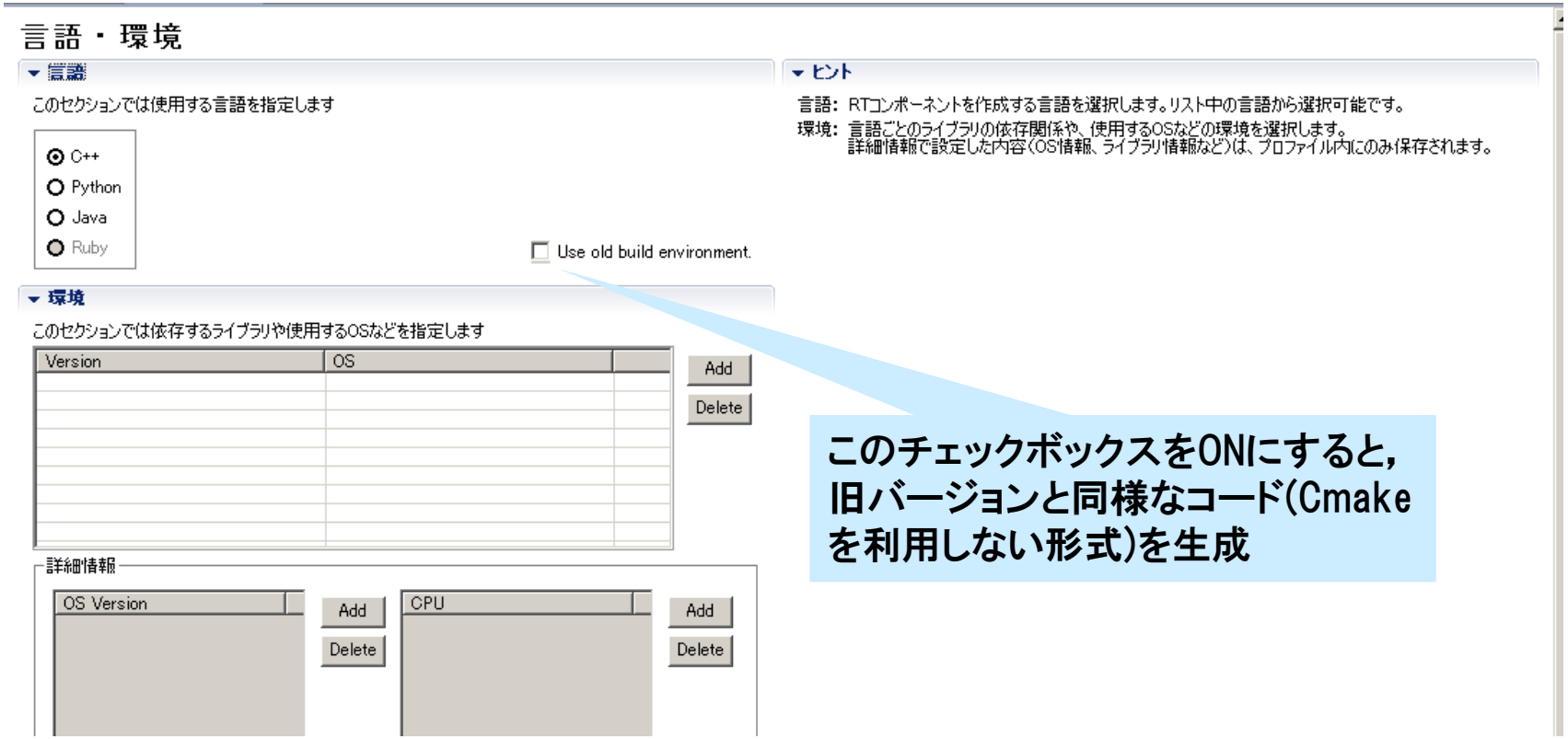
- Entering constraints
  - No constraints: Blank
  - Direct: Use the value as-is
    - e.g. 100
  - Range:<, >, <=, >=
    - e.g. 0<=x<=100
  - Enumeration: (値1, 値2, ・・・)
    - e.g. (val0, val1, val2)
  - Array: Value 1, Value 2, ・・・
    - e.g. val0, val1, val2
  - Key-value: { Key 0:Value 0, Key 1:Value 1, ・・・ }
    - e.g. { key0:val0, key1:val1}

- Widget
  - text (Default)
  - slider
    - For numerical values with a range
    - Set the step size with “step”
  - spinbox
    - For numerical values with a range
    - Set the step size with “step”
  - radio button
    - For enumerations

※When the widget and constraints do not match, text is used.

# Language and environment

- Set the language to generate and environment settings

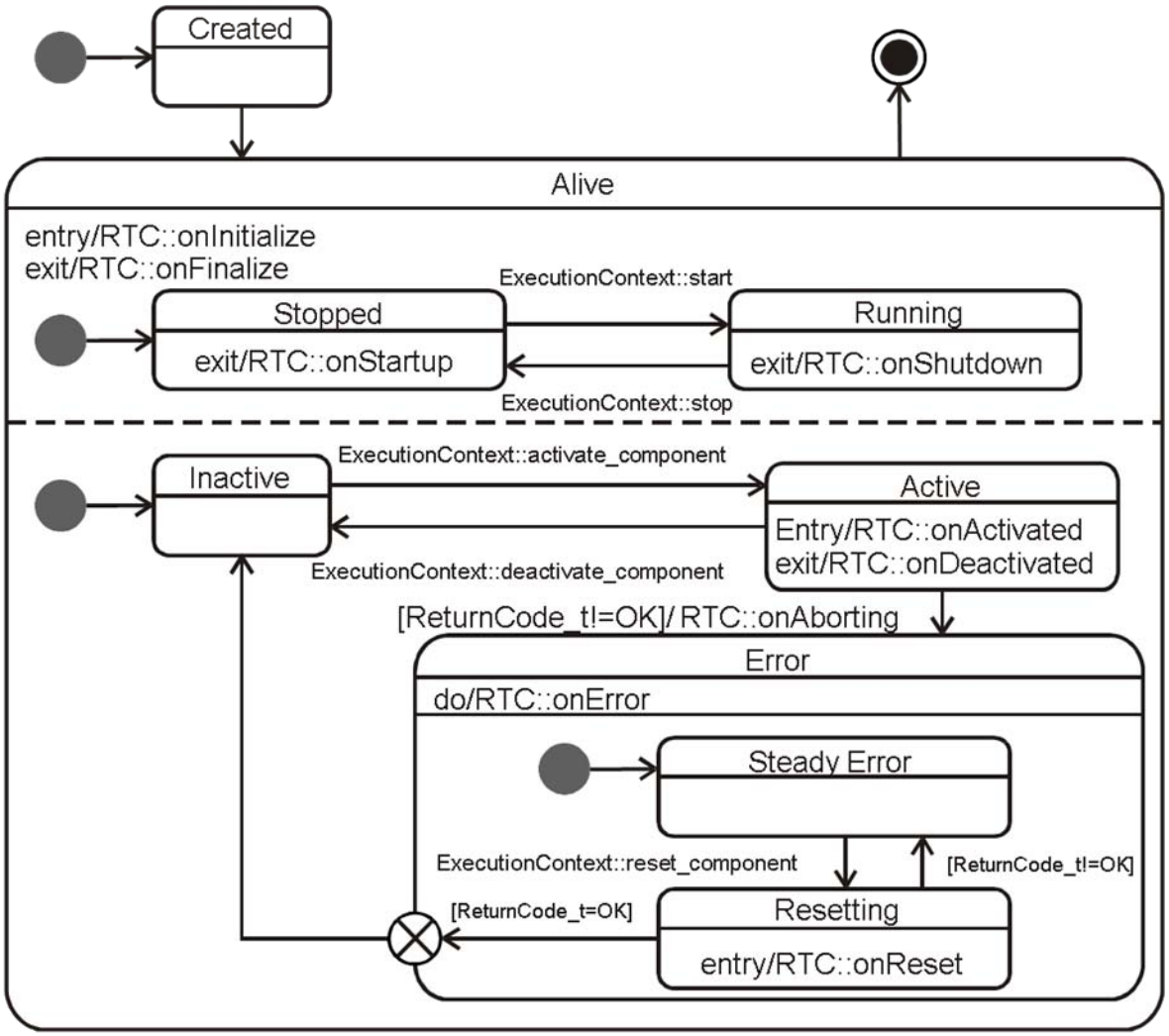



Select C++

# Generating the RT-Component

# Implementing an RT Component

- RTC states
  - Created
  - Alive
    - Inactive
    - Active
    - Error
  - Finalised




RTC lifecycle (UML state chart)

# Implementing an RT Component

## Available call-back functions

| 関数名 | 概要 |
|---|---|
| onInitialize | Called once when the lifecycle starts. |
| onActivated | Called once when the component is activated. |
| onDeactivated | Called once when the component is deactivated. |
| onExecute | Called regularly while the component is active. |
| onStateUpdate | Called after onExecute. |
| onAborting | Called once when changing to the Error state. |
| onError | Called regularly while in the Error state. |
| onReset | Called once when leaving the Error state. |
| onShutdown | Called once when the EC shuts down. |
| onStartup | Called once when the EC starts. |
| onFinalize | Called once when the lifecycle ends. |

# Implementing the component

- **Make a component from an existing program.**

```
int main (int argc, char** argv) {
  // カメラからの画像をキャプチャするクラスのインスタンスを生成
  ds_Camera *cam;
  cam = new ds_Camera();

  // キャプチャクラスのオブジェクトの初期化
  cam->initialize();

  while(1) {
    // カメラからの画像キャプチャ処理
    cam->capture();

    // 画像を表示
    cvShowImage("Capture", cam->getImage());
    cvWaitKey(2);
  };

  // キャプチャクラスのオブジェクトの終了処理
  cam->finalize();

  // キャプチャクラスのオブジェクトの破棄
  delete cam;

  return 0;
}
```

RTC::onInitialize()

RTC::onActivated()

RTC::onExecute()

RTC::onDeactivated()

USBCamera RTC source

# Implementing the component

- To make this an RTC:

```
RTC::ReturnCode_t USBCamera::onInitialize() {
  // Set OutPort buffer
  addOutPort("image", m_imageOut);
  // Bind variables and configuration variable
  bindParameter("deviceNumber", m_deviceNumber, "0");

  //Create an instance of the camera class
  cam = new ds_Camera();
  return RTC::RTC_OK;
}
```

```
RTC::ReturnCode_t USBCamera::onFinalize() {
  // Delete the camera object
  delete cam;
  return RTC::RTC_OK;
}
```

# Implementing the component

- To make this an RTC:

```
RTC::ReturnCode_t
USBCamera::onActivated(RTC::UniqueId ec_id) {
  // Initialise the camera object
  if(cam->initialize())
    return RTC::RTC_OK;
  return RTC::RTC_ERROR;
}
```

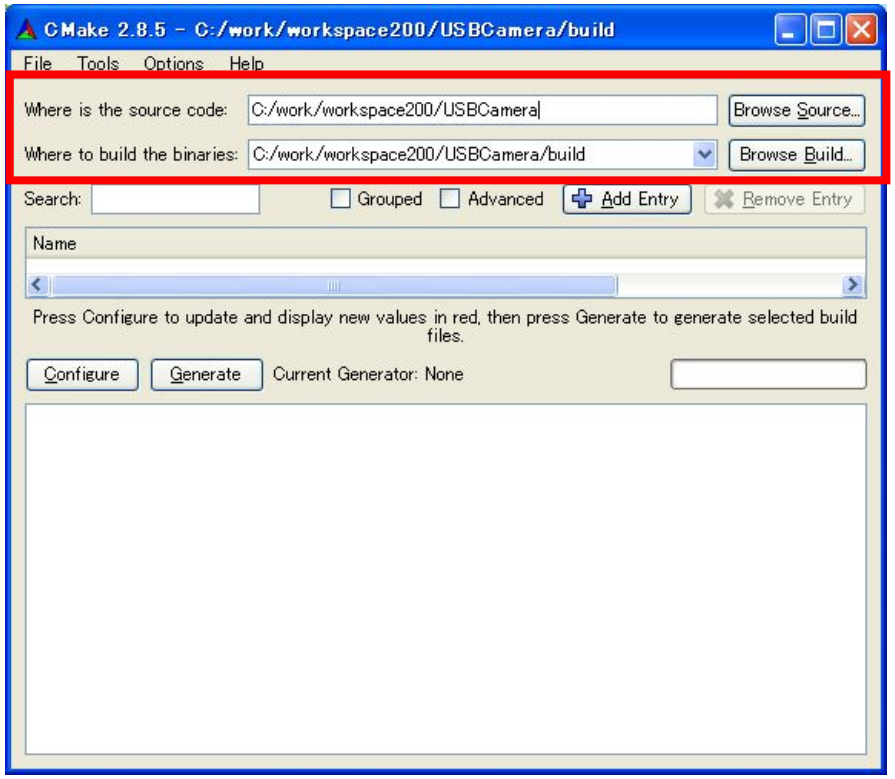
```
RTC::ReturnCode_t
USBCamera::onDeactivated(RTC::UniqueId ec_id) {
  // Shut down the camera object
  cam->finalize();
  return RTC::RTC_OK;
}
```

# Implementing the component

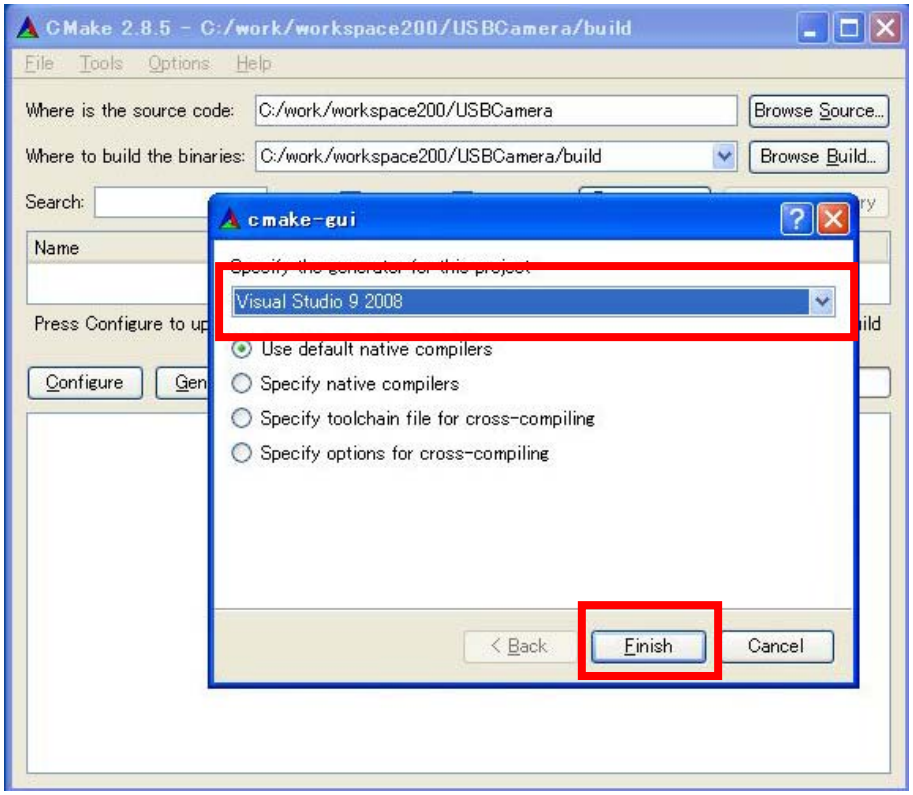
```
RTC::ReturnCode_t USBCamera::onExecute(RTC::UniqueId ec_id) {
  // Capture an image from the camera
  if (cam->capture() < 0)
    return RTC::RTC_OK;

  // Get the image size
  int len = cam->getImageSize();
  CvSize size = cam->getSize();

  // Set up the output data
  m_image.pixels.length(len);
  m_image.width  = size.width;
  m_image.height = size.height;

  // Add the image data to the output
  memcpy((void *)&(m_image.pixels[0]), cam->getImageData(), len);

  // Write the output
  m_imageOut.write();

  return RTC::RTC_OK;
}
```

# Compiling (Windows, CMake)

①Start the CMake GUI and specify the source and binary directories.



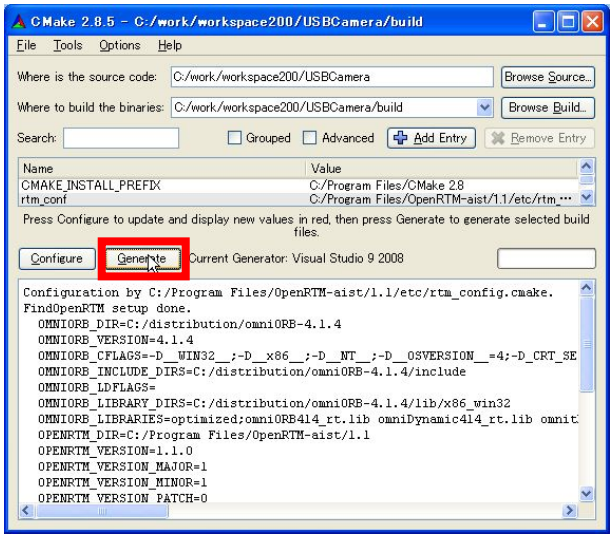

②Press “Configure” and select the platform to build for.

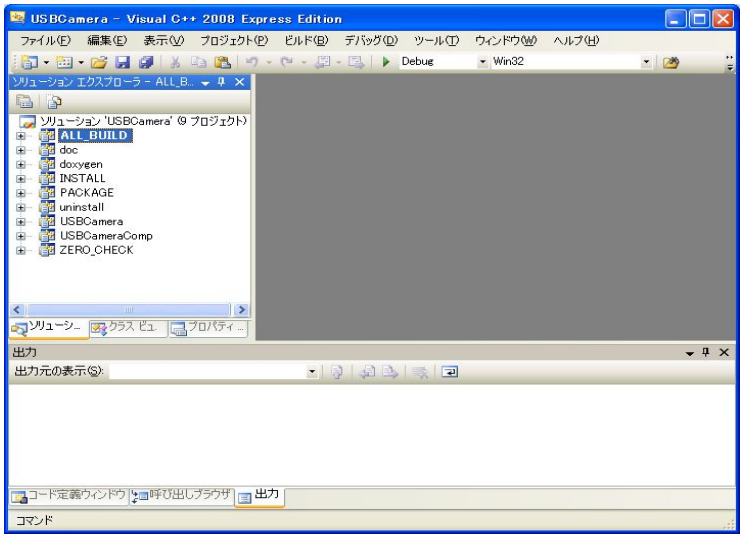


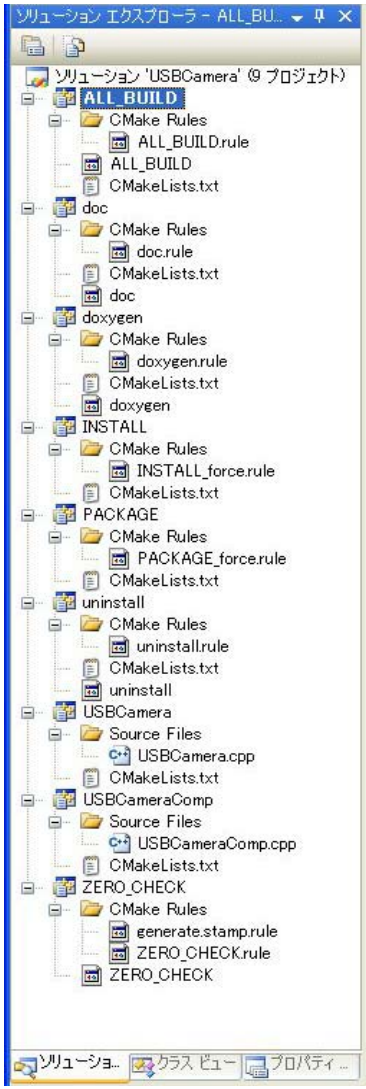

※Specify separate directories for the binary and source directories.

# Compiling (Windows, CMake)

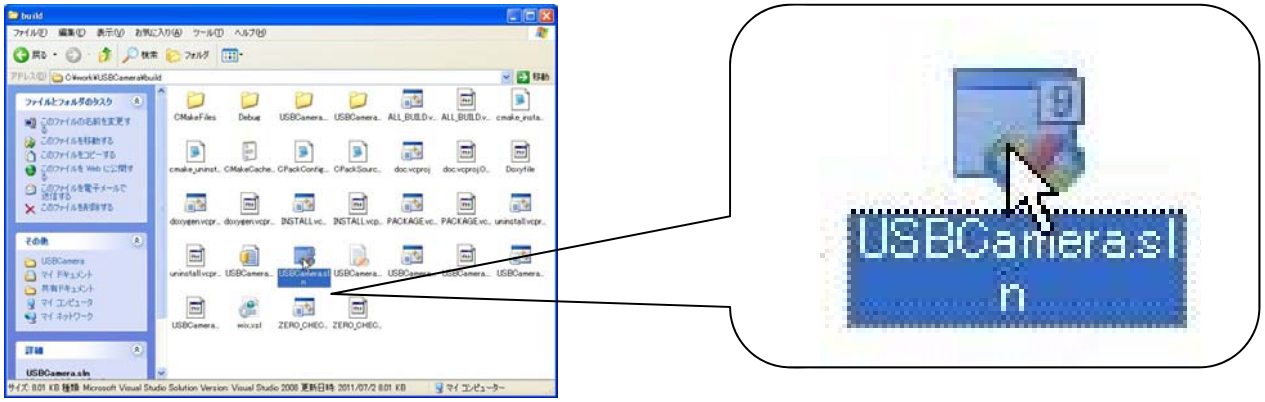
## ③Click “Generate” once configuration has completed.



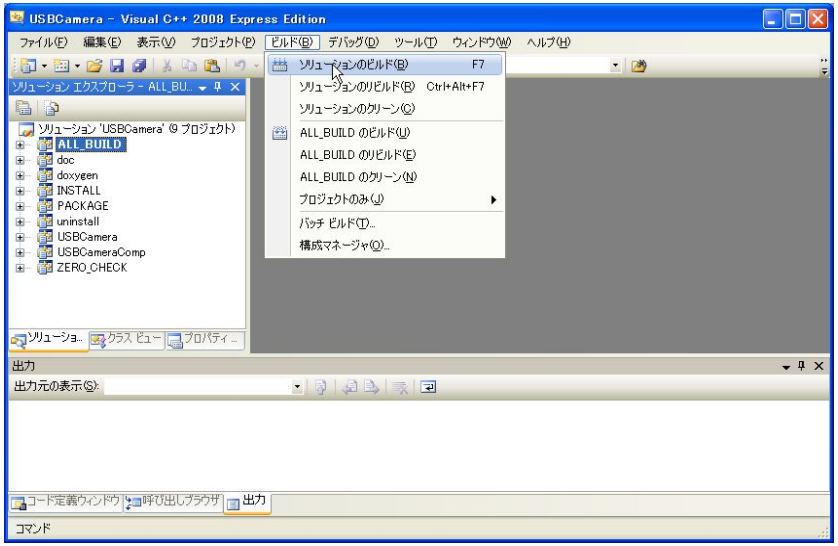




## ④Open the solution file in the binary directory.

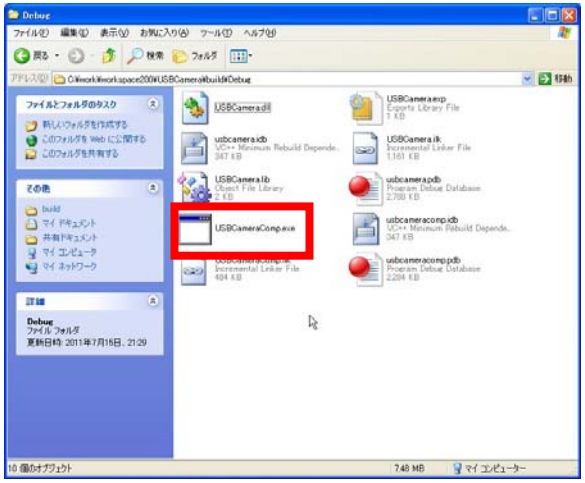


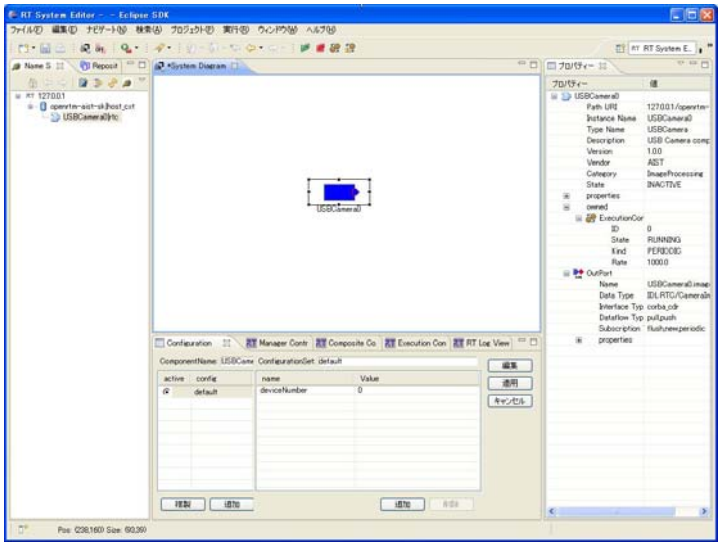
# Compiling (Windows, CMake)

## ⑤Build the solution



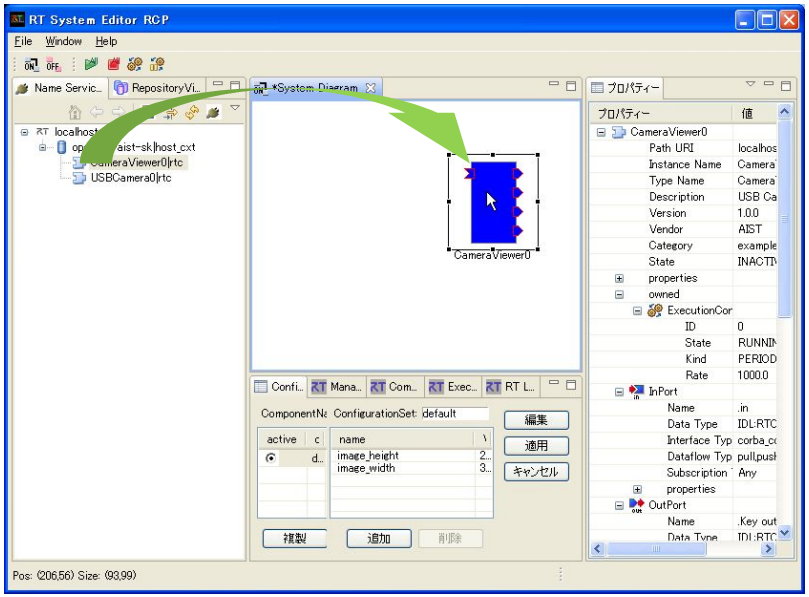

## ⑥In the “Debug” directory of the binary directory, start the component.

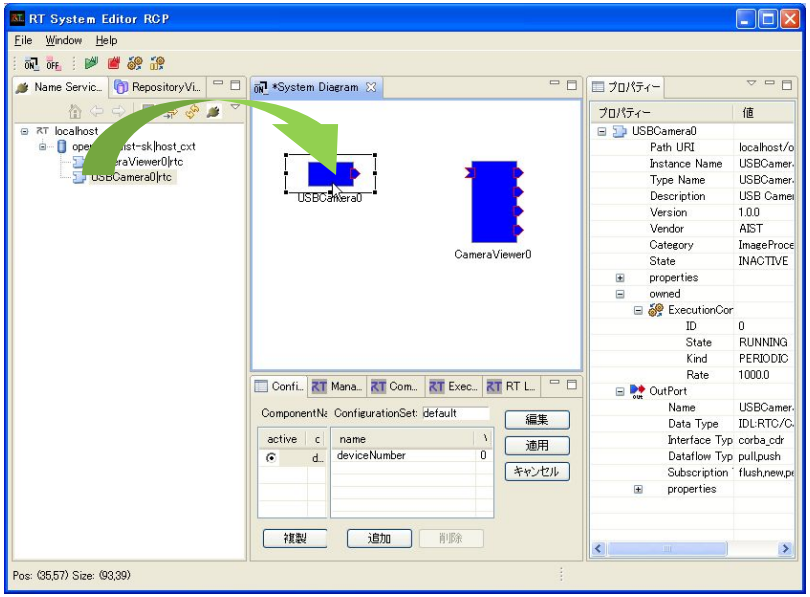


# Check operation

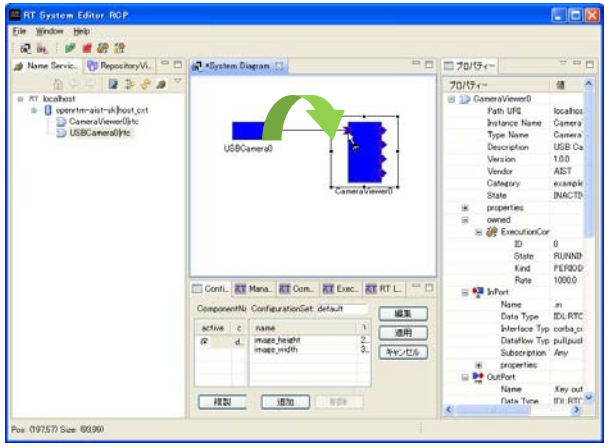
1. Start the CameraViewer
   - [Start menu]→[All programs]→[OpenRTM-aist 1.1]→[C++]→[components]
     →[opencv_rtcs]→[CameraViewerComp.exe]
2. Connect the components.
   Drag and drop the components into the system editor.



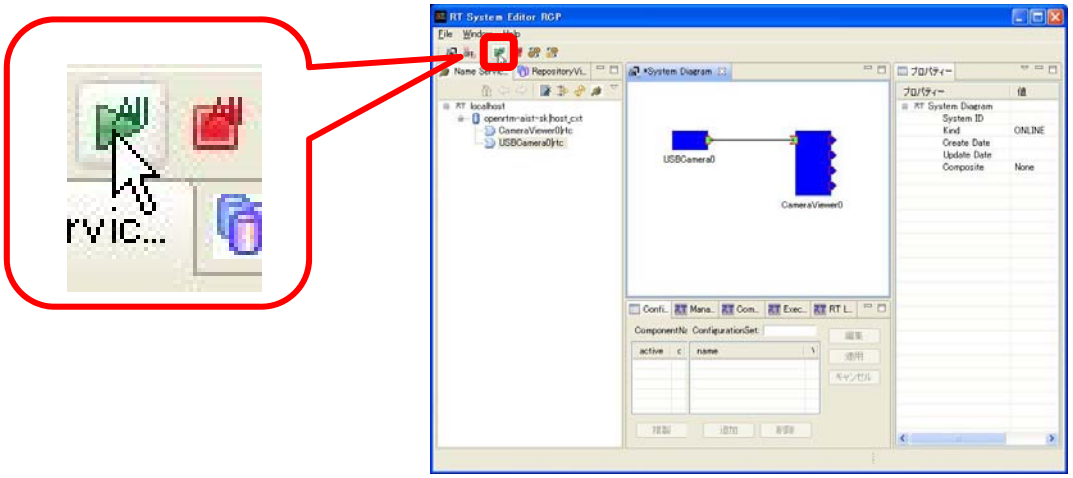



# Check operation

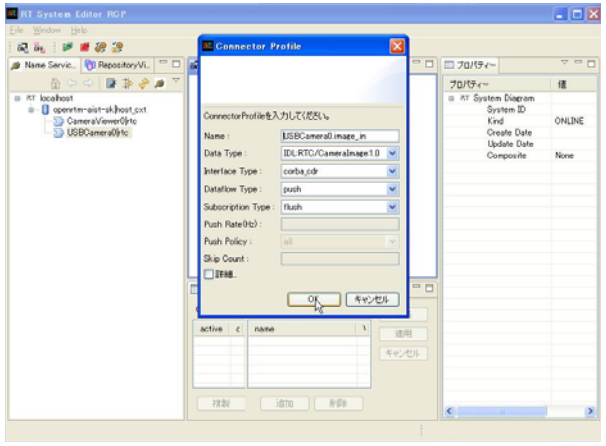
3. Connect the ports.



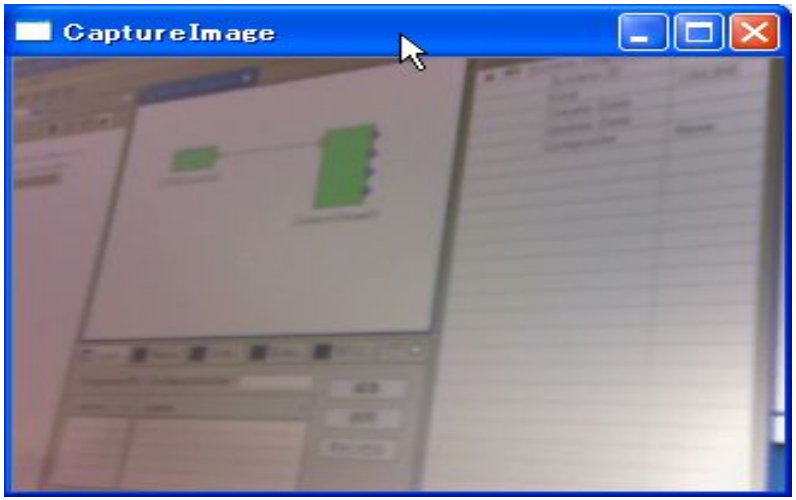
5. Activate the components.



4. Use the default profile.

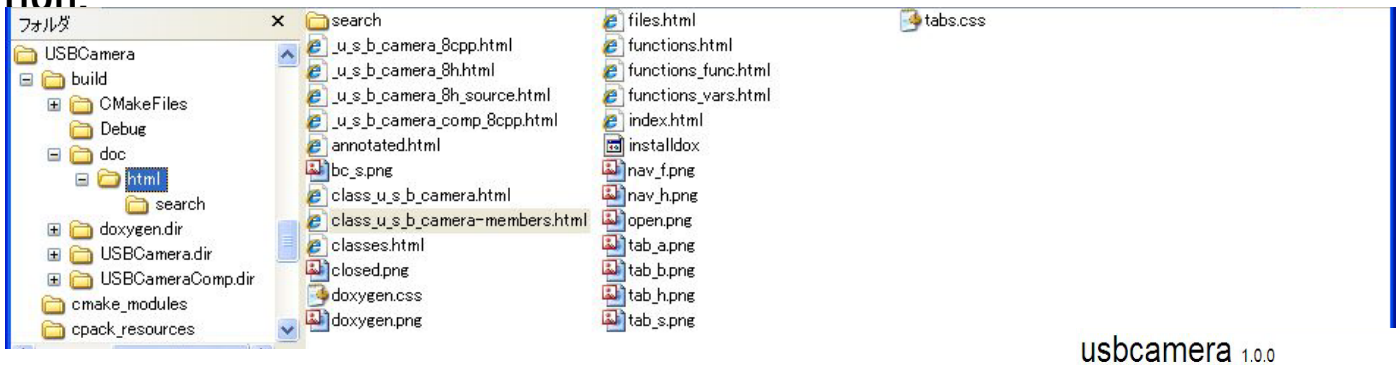


6. The camera image will be displayed.

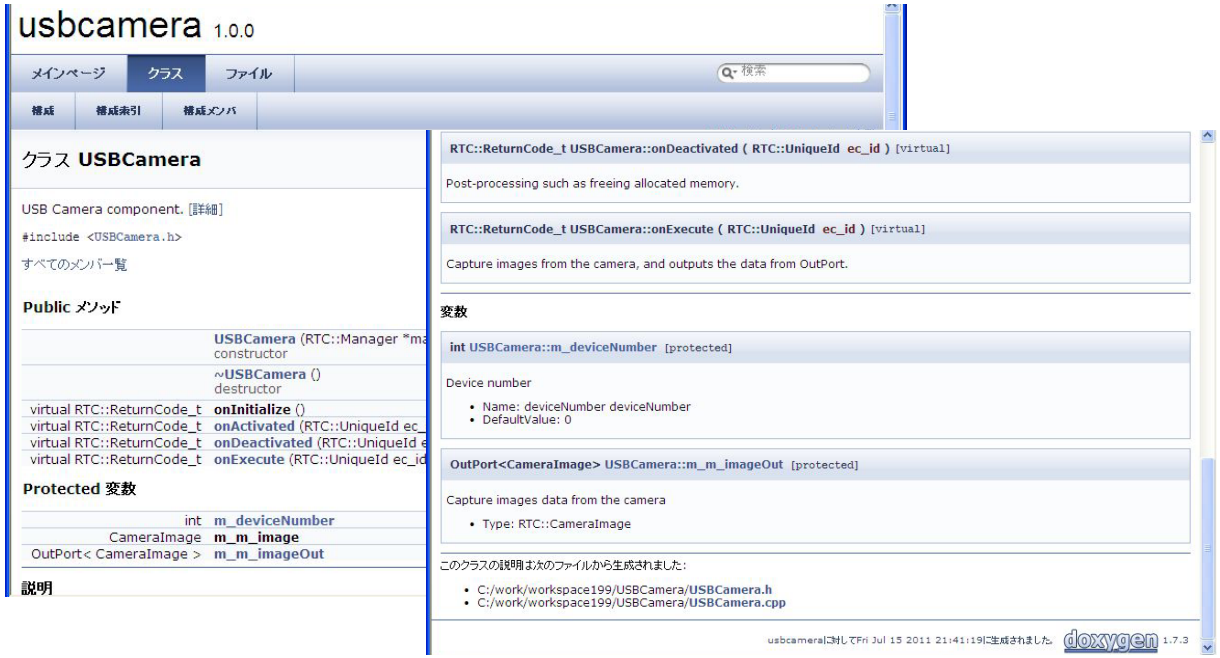


# Document generation (Windows, CMake)

※The doc/html/ directory in the binary directory contains Doxygen-generated documentation.

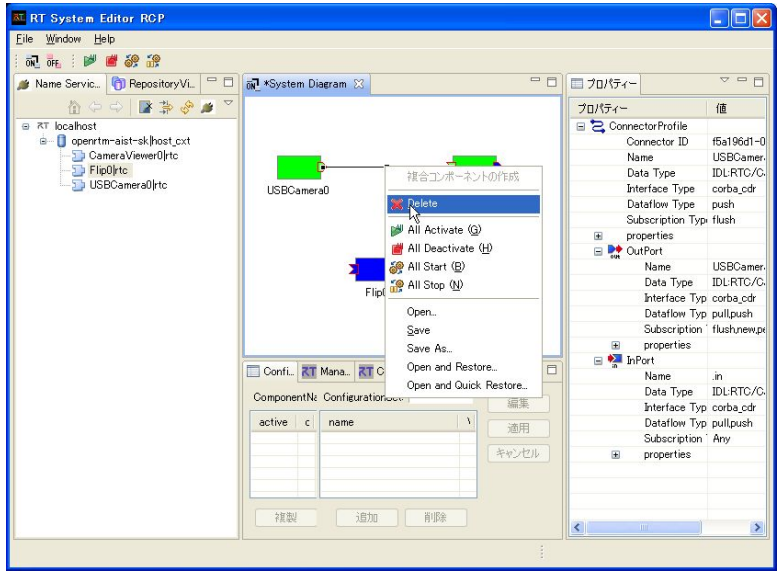



- Example:



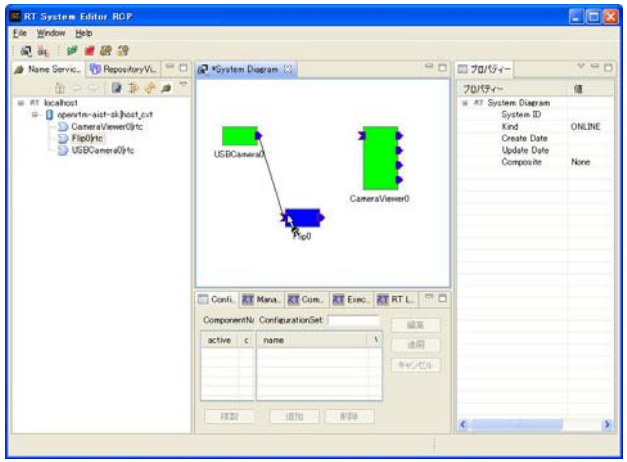
# Add some more components

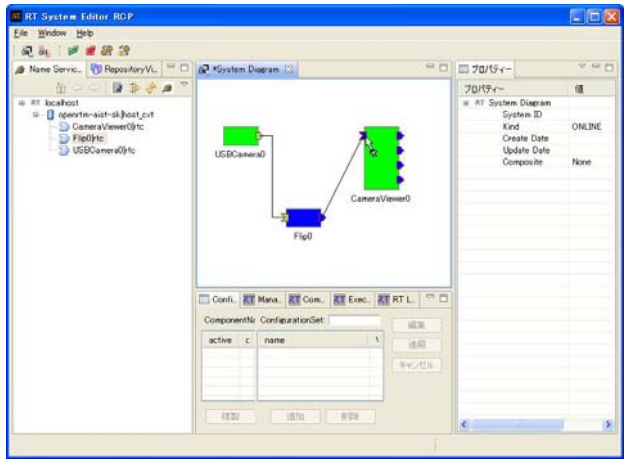
1. Start the Flip component
   - [Start menu]→[All programs]→[OpenRTM-aist 1.1]→[C++]→[components]→[opencv_rtcs]→[FlipComp.exe]
2. Add the Flip component to the system editor.
3. Disconnect the USBCamera and CameraViewer components.
   (1) Select the connection line.
   (2) Right-click on it.
   (3) Click “Delete.”

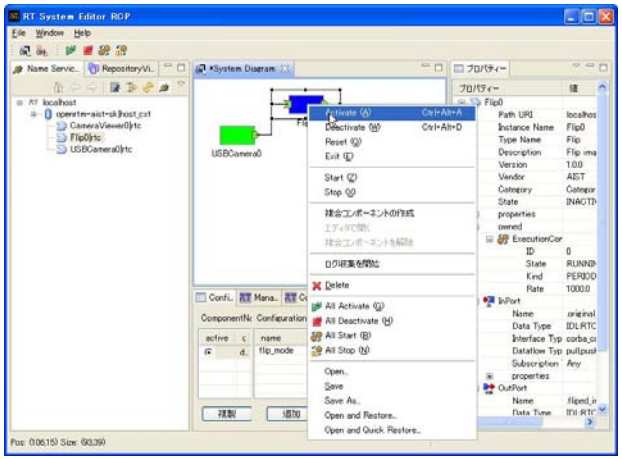


# Add some more components

1. Connect USBCamera's OutPort to Flip's InPort.
2. Connect Flip's OutPort to CameraViewer's InPort.
3. Activate the Flip component.
   (1) Right-click on Flip.
   (2) Select "Activate" from the context menu.

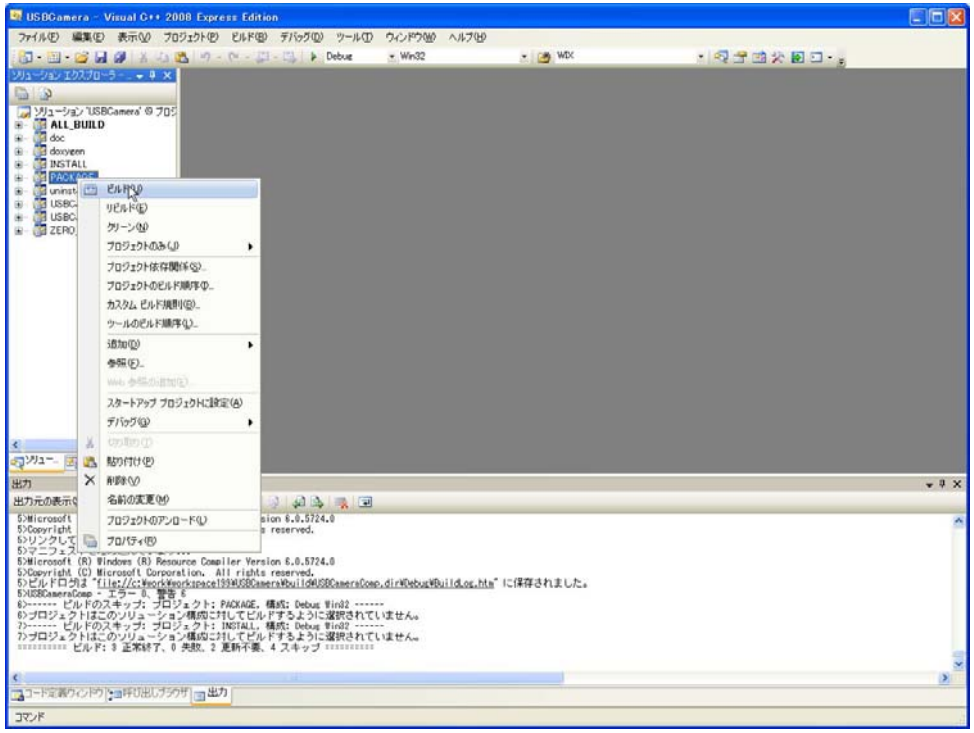


# Distributable package generation

- Build the “PACKAGE” target in the solution.

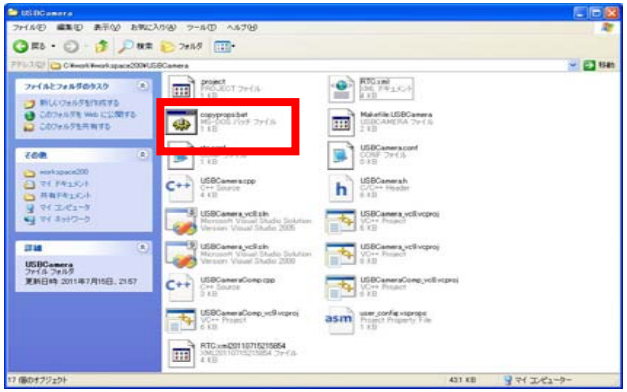



- An MSI installer is generated in the binary directory.
  - The component is installed into:
    C:/Program Files¥OpenRTM-aist/1.1/components/<Language>/<Package name>

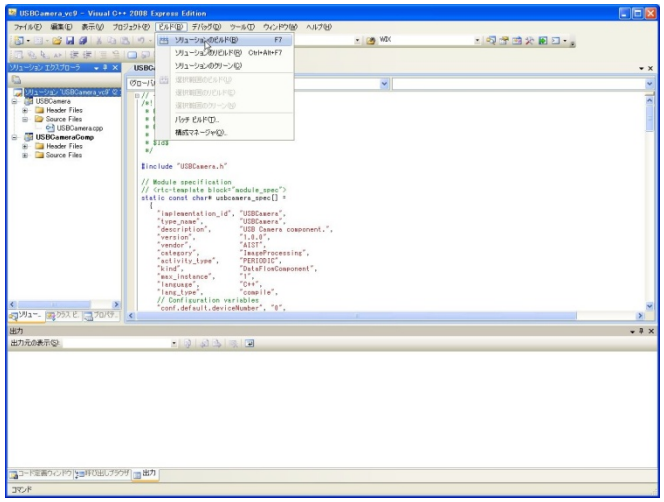
# Supplement

# Compiling on Windows without CMake

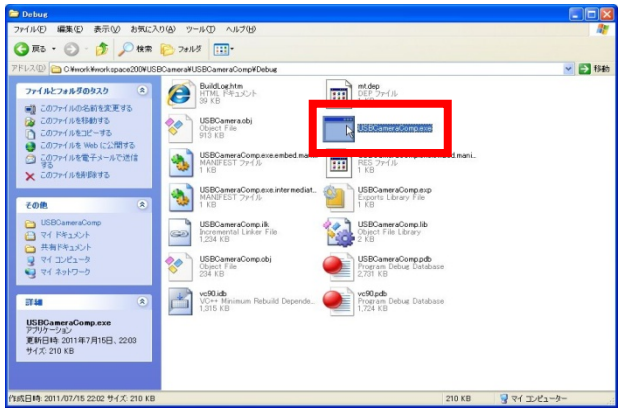
①Execute “copyprobs.bat” in the generated code directory to copy the properties files.

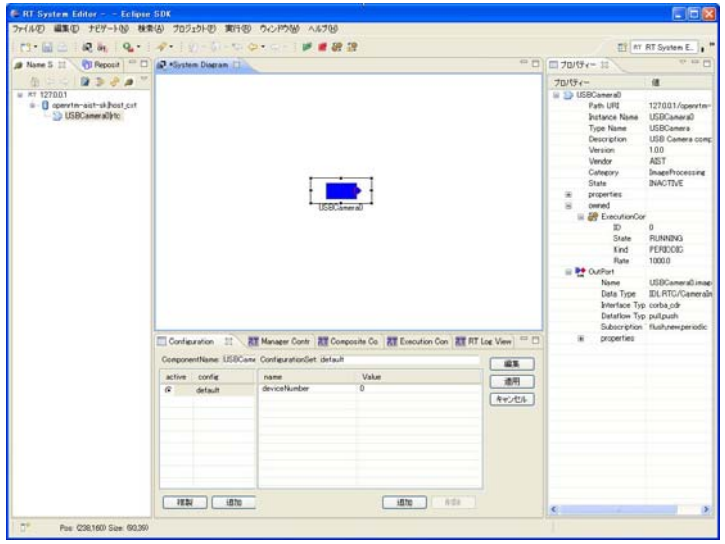


②Build with Visual Studio



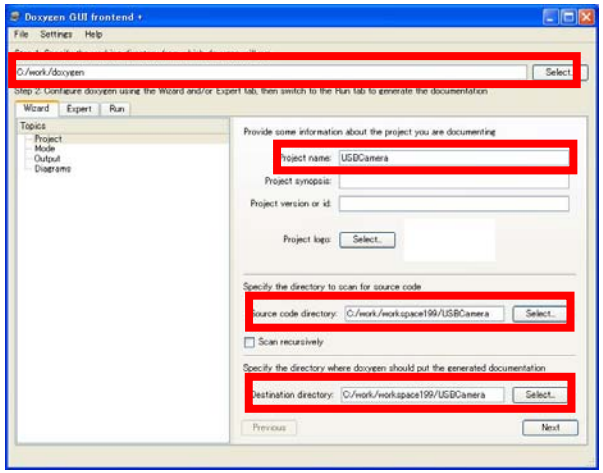
③In the USBCameraComp/Debug directory, execute USBCameraComp.exe



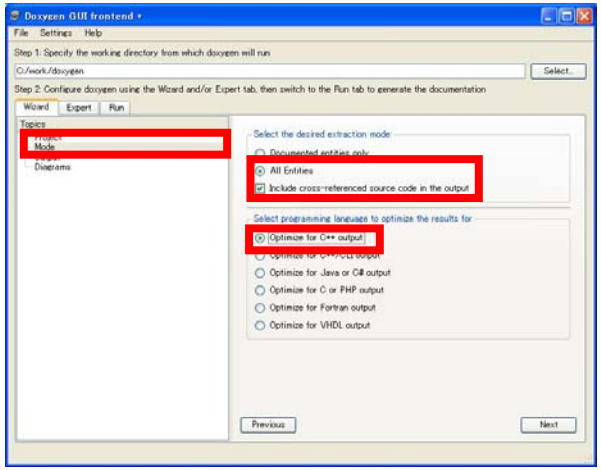


# Document generation without CMake

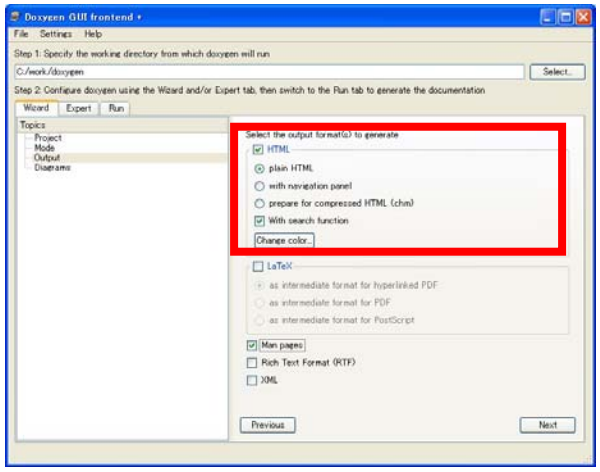
①Start the Doxygen GUI tool.
Set the directories and project name.



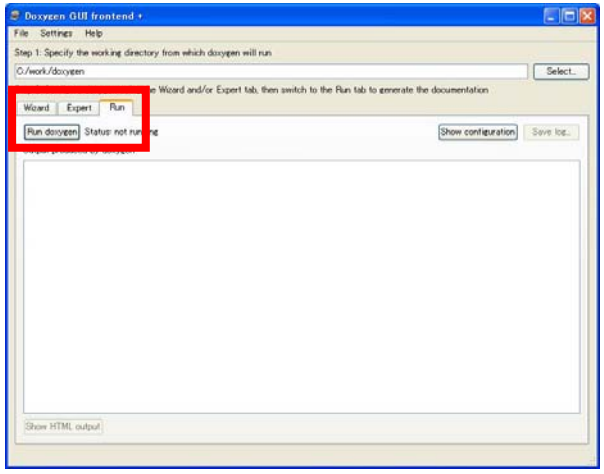

②Set the output and language settings in the “Mode” section.




③In the “Output” section, select HTML.



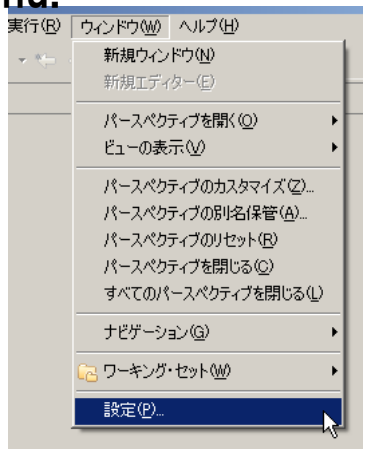

③Click “Run Doxygen” in the Run tab.



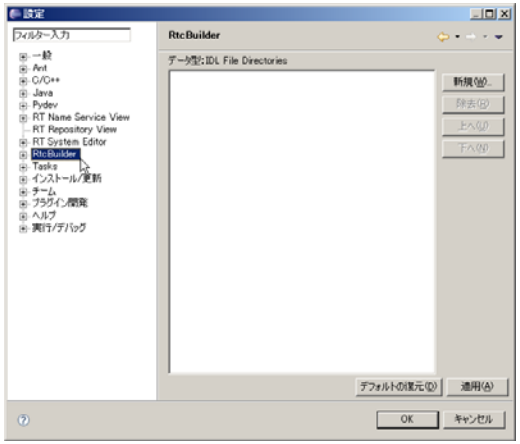
# Various settings

- Specify data types available for DataPorts by specifying the directories containing the IDL files.

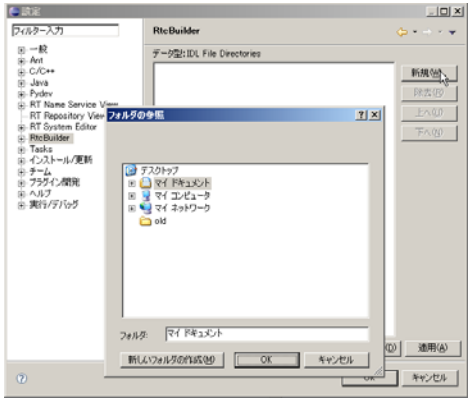
①Select “Settings” from the “Window” menu.




②Select “RtcBuilder.”




③Click the “Append” button and select the directory.




※Only necessary when using your own IDL files. The OpenRTM-aist default data types are set automatically.

・Default data types are available at [RTM_Root]rtm/idl
→BasicDataType.idl, ExtendedDataTypes.idl, etc.
→By default, [RTM_Root]=C:/Program Files/OpenRTM-aist/1.1/

# SICE 2011
# RT-Middleware Tutorial