

# Software Architecture in Action

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# Chapter 13

## Pipe-Filter Architectural Style

# Learning outcomes of this chapter

## ■ You will learn:

- what is a Pipe-Filter architectural style
- what are its elements, structure and behavior
- the pipeline substyle

# The structure of this chapter

- Conceptual Overview
- Pipe-Filter structural viewpoint
- Pipe-Filter behavioral viewpoint
- The Pipeline substyle
- Summary



# Conceptual Overview

# Pipe-Filter

## Conceptual overview – 1/2

- In the Pipe-Filter style components and connectors have a particular behavior and should be configured to allow a sequential processing of data.
- Components called “filters” read streams of data on its inputs and produces streams of data on its outputs, typically applying a local transformation to each element of the input streams and incrementally computing the corresponding elements of the output streams.
- Connectors “pipes” serve as conduits for the streams, transmitting outputs of one filter to inputs of another.

# Pipe-Filter

## Conceptual overview – 2/2

- An example of the use of the pipe-filter style in the RTC System is an architecture with distributed temperature sensors with no direct communication with the controller. Instead, they are connected with their adjacent sensors in a sequence.

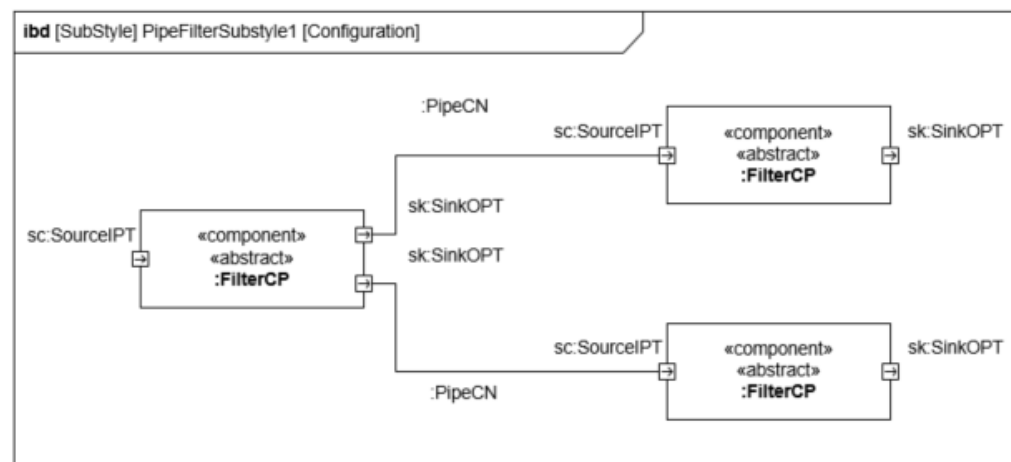
# Pipe-Filter

## Pipe-Filter in SysADL

### Pipe-Filter Use

- We can use the pipe-filter style to model a part of the system that has a sequential dataflow that is transformed by the filter component
  - The filter component acts as filter to transform the flowing data
  - Each filter component has at least an in port (Source) or an out port (Sink)
  - The connector acts as a pipe to conduct data from a sink in one component to a source in other component
  - The components are sequentially connected

### Use in SysADL





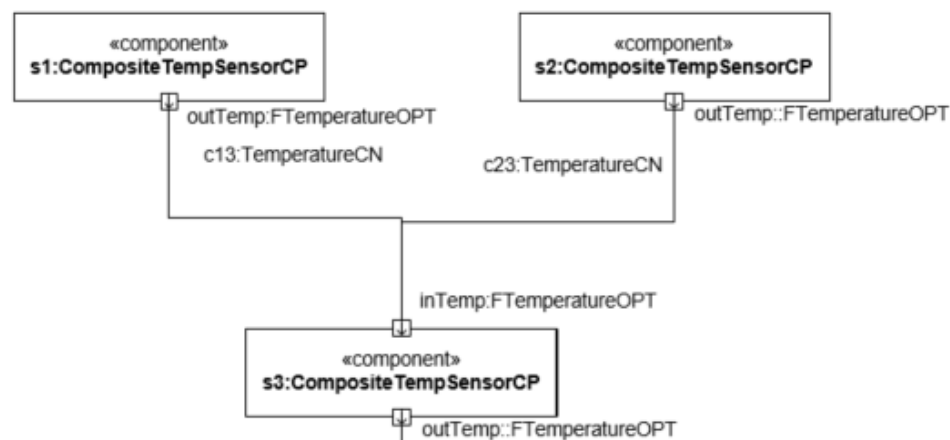
# Pipe-Filter

## Example in SysADL

### Pipe-Filter Example

- In this example, we have composite temperature sensors in a pipe-filter architecture
  - the *CompositeTempSensorCP* has an internal temperature sensor and a component that sends temperature values it receives in its in port
  - *s1*, *s2* and *s3* are filters and *c13* and *c23* are pipes in this architecture
  - *s1* and *s2* are connected to *s3*
  - *s3* receives the temperature and sends it to the *outTemp* port

### Example in SysADL





# Pipe-Filter Structural Viewpoint

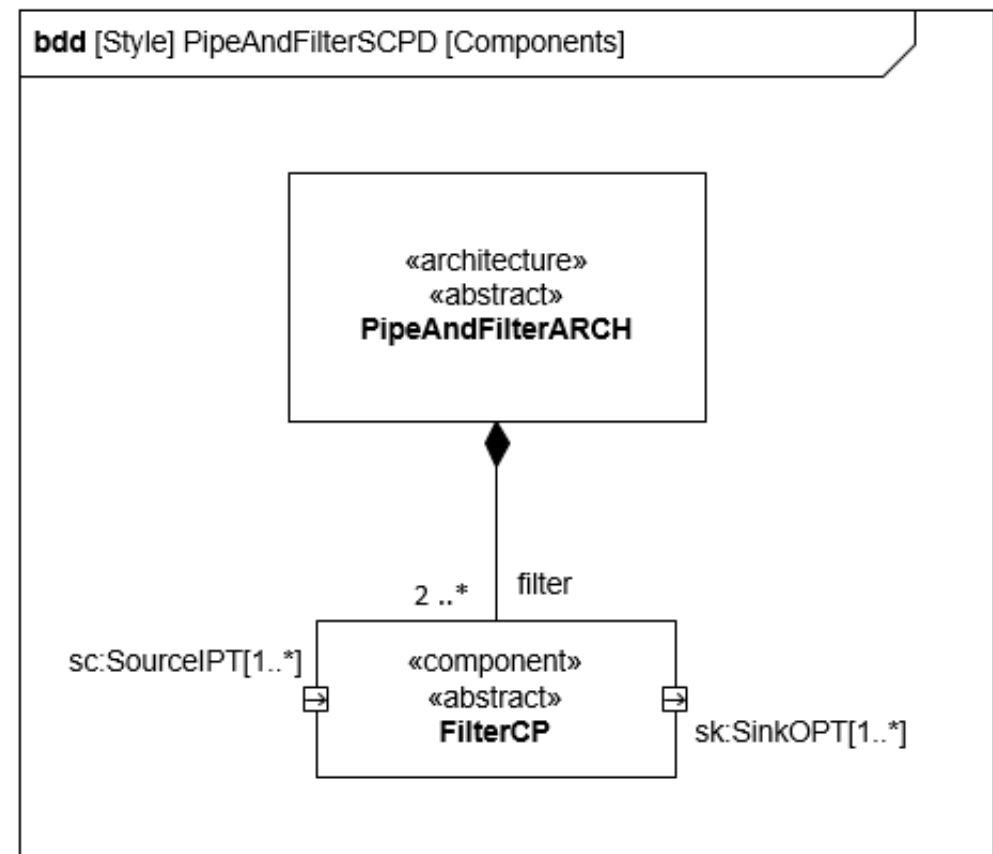
# Pipe-Filter Components

## Component Definition in SysADL

### Pipe-Filter Components

- We define the Pipe/Filter architectural style using a bdd
  - The Pipe/Filter Architecture Style (PipeAndFilterARCH) is composed of at least 2 Filter Component (FilterCP)
  - Each Filter component can have at least one in port (SourceIPT) and one out port (SinkOPT)
  - As a convention we name the bdd as PipeAndFilterSCPD – SCPD means Style Component Definition
  - All components must be connected by at least one filter

### Components in SysADL



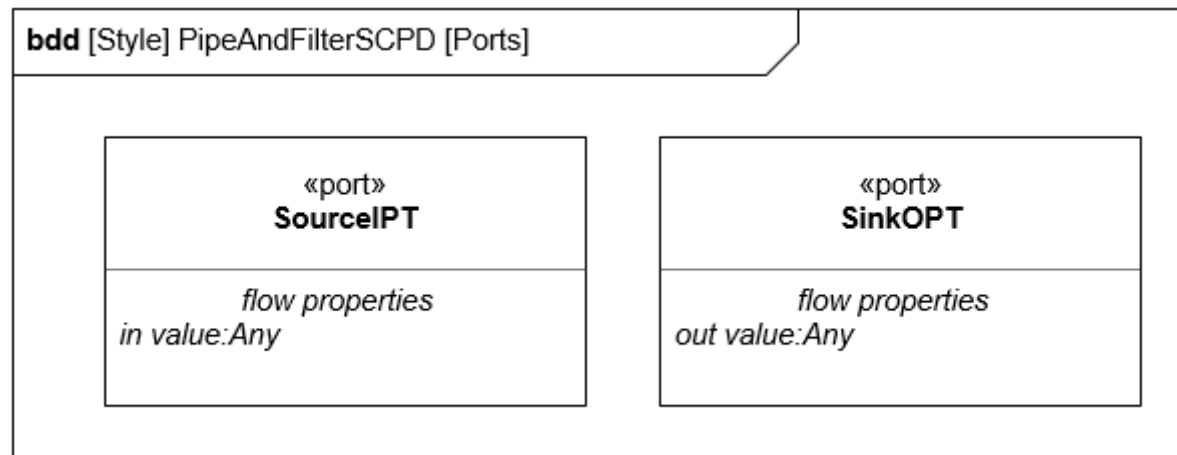
# Pipe-Filter Ports

## Ports Definition in SysADL

### Ports Definition

- In the Pipe-Filter architectural style definition, we must also define the ports of a Filter
  - the SourceIPT port receives values of any type
  - the SinkOPTport send values of any type

### Ports in SysADL



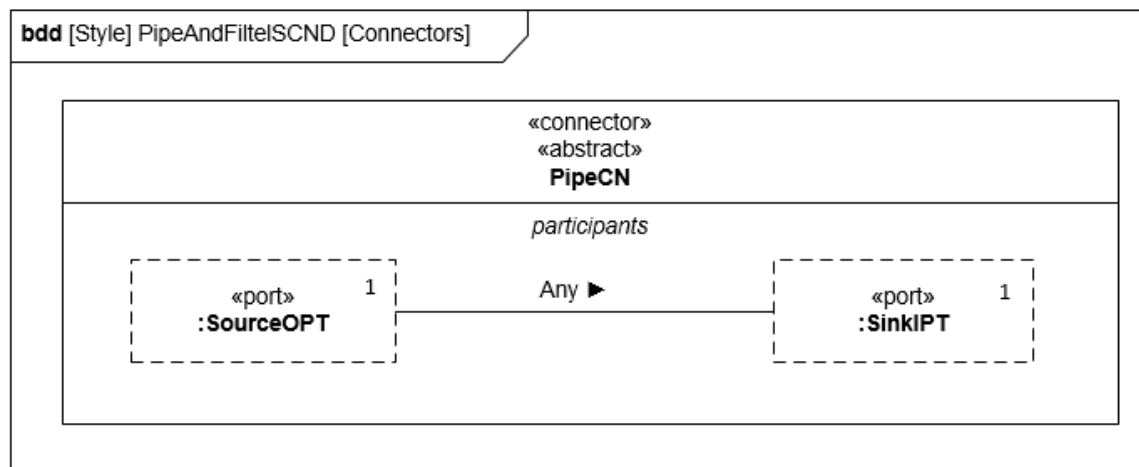
# Pipe-Filter Connectors

## Ports in SysADL

### Connectors Definition

- In the Pipe-Filter architectural style definition, we must also define the pipe connector
  - the PipeCN connector has two participants: one SourceOPT port and one SinkIPT port
  - the PipeCN connector allow any type of data to flow from the SourceOPT port to the SinkIPT port

### Connectors in SysADL





# Pipe-Filter Behavioral Viewpoint

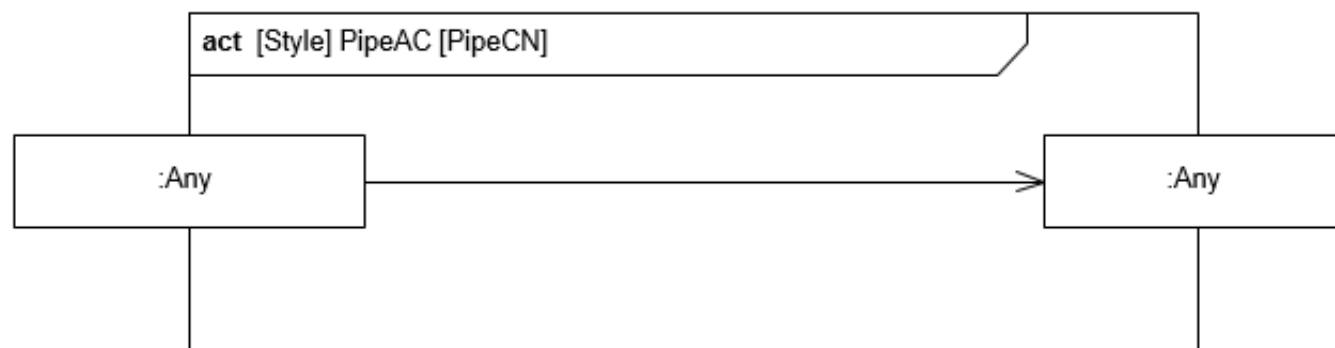
# Pipe-Filter Behavior

## Connector Behavior in SysADL

### Connector Behavior

- We define the behavior of the Pipe connector using activity diagrams
- the connector sends a value directly from the input pin to the output pin

### Pipe-Filter Port Protocol



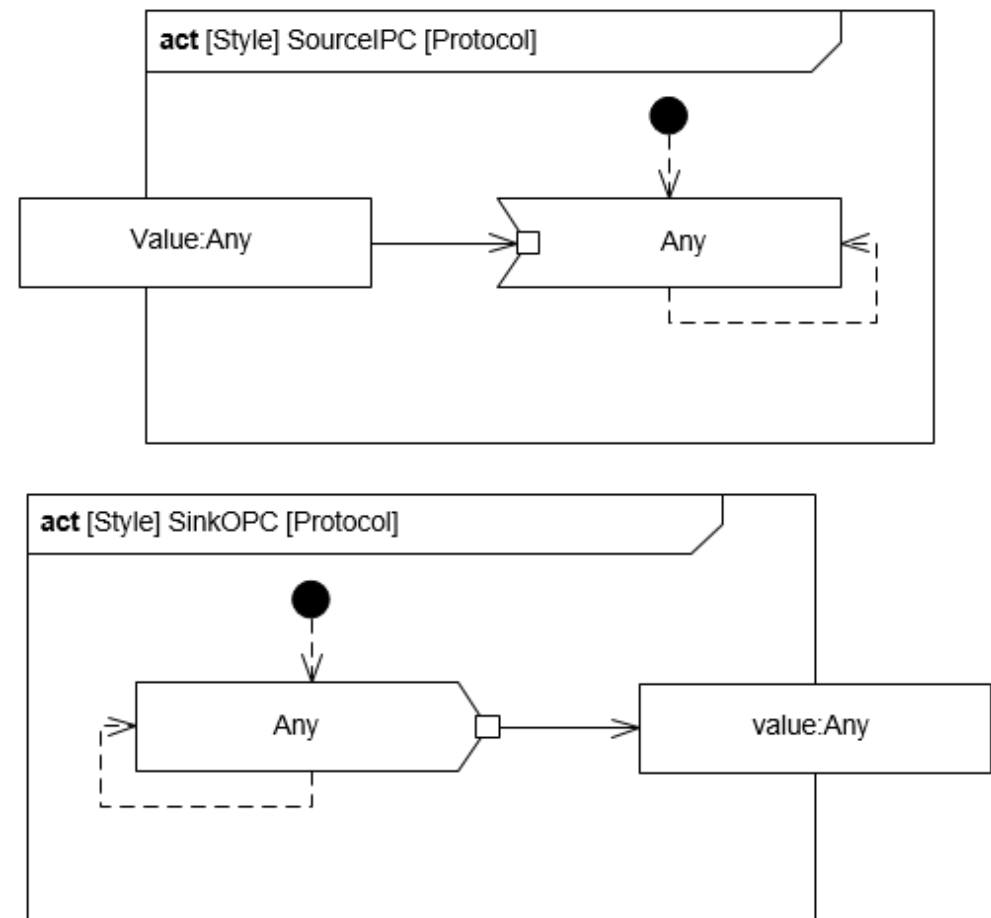
# Pipe-Filter Behavior

## Port Protocol

### Pipe-Filter Port Protocol

- We define the protocol of the ports using activity diagrams
  - the SourceIPC protocol states that the port repeatedly receives values of any type
  - the SinkOPC protocol states that the port repeatedly sends values of any type

### Port Protocol in SysADL







# Pipeline Substyle

# Pipeline substyle

## Conceptual overview

- A Pipeline is a substyle of the Pipe-Filter style where all filters are sequentially connected
  - Each filter has at most one predecessor and one successor
- An example of the use of the pipe-filter style in the RTC System is an architecture with distributed temperature sensors with no direct communication with the controller. Instead, they are connected with their adjacent sensors in a sequence.

# Pipeline Substyle

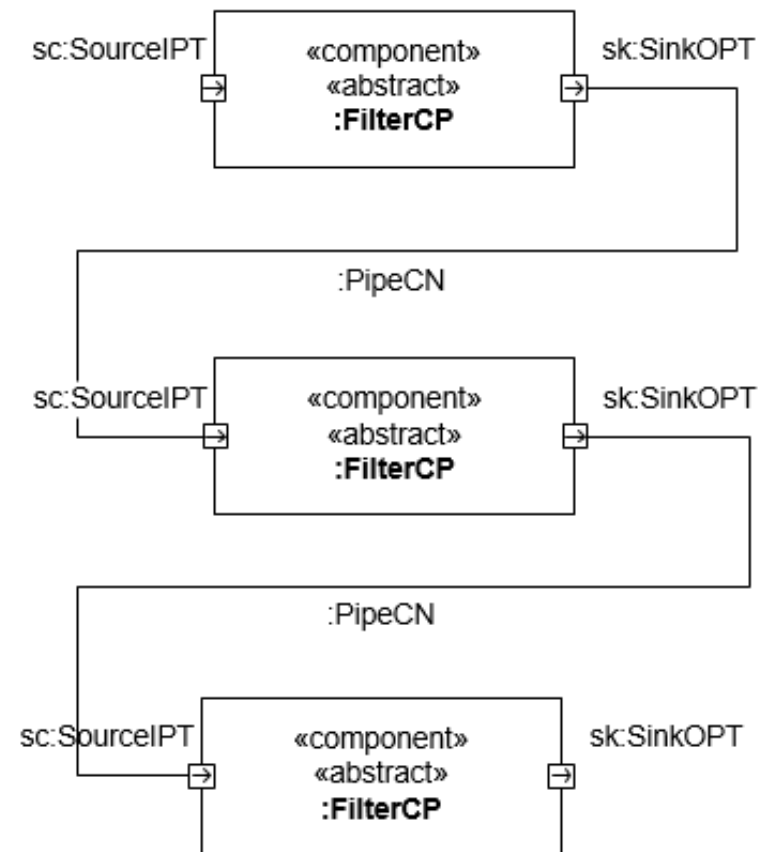
## Use in SysADL

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### Pipeline Use

- We can use the pipe-filter style to model a part of the system that has a sequential dataflow that is transformed by the filter component
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### Pipe-Filter in SysADL



# Pipe-Filter

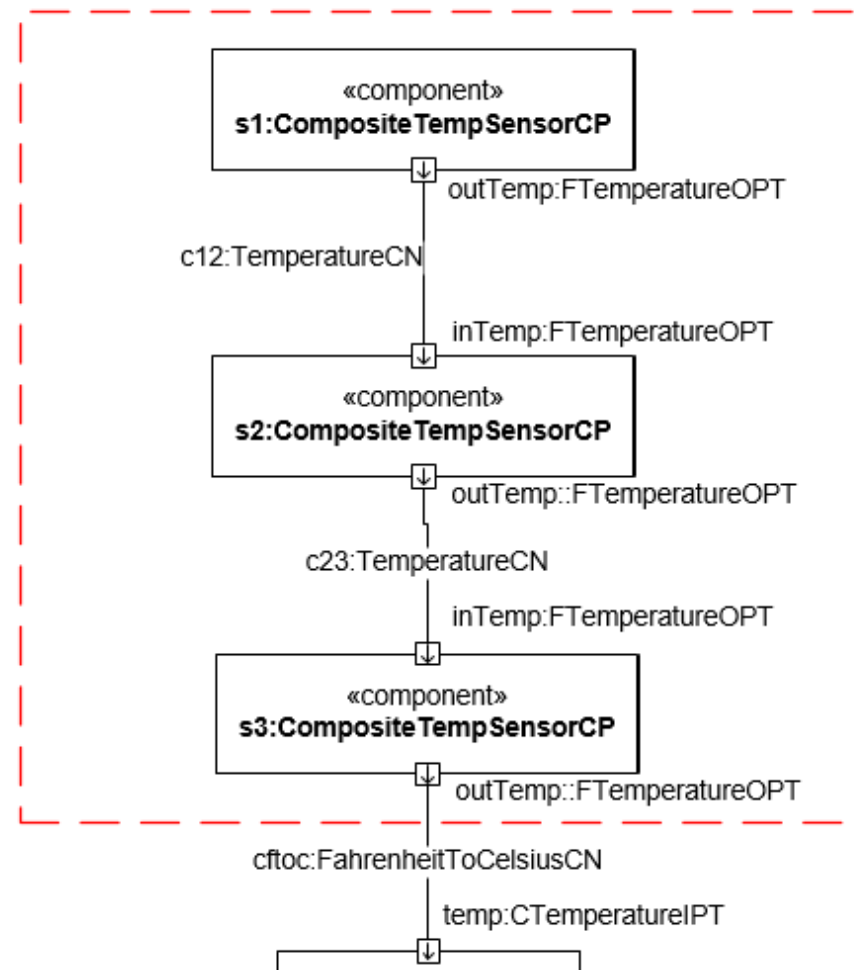
## Example

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### Pipe-Filter Example

- In this example, we have composite temperature sensors in a pipeline architecture
  - the *CompositeTempSensorCP* has an internal temperature sensor and a component that sends temperature values it receives in its in port
  - s1, s2 and s3 are filters and c12 and c23 are pipes in this architecture
  - s1 is connected to s2 and s2 is connected to s3
  - s2 and s3 receive the temperature and sends it to the *outTemp* port

### Example in SysADL



# Summary

- In this chapter you learnt
  - the Pipe-Filter architectural style
  - the elements, structure and behaviour of the Pipe-Filter style
  - the Pipeline substyle
- You learnt how to:
  - Apply the Pipe-Filter style in an architecture design

# For Further Reading

- Clements, P.; Bachmann, L.; Garlan, D.; Ivers, J.; Little, R.; Merson, P.; Nord, R. Documenting Software Architecture: Views and Beyond. SEI Series in Software Engineering. (2003)
- Buschmann, F., Meunier, R., Rohnert, H. Sommerlad, P., Michael Stal, M. Pattern-Oriented Software Architecture Volume 1: A System of Patterns. Vol. 1. Wiley (1996).
- Vogel, O.; Arnold, I.; Chughtai, A.; Kehrer, T. Software Architecture: A Comprehensive Framework and Guide for Practitioners. Springer (2011)