Systems *Engineering: Design and Development*

ENGR 387

Agenda

- **PAR Diagrams**

- **Purpose of PAR Diagrams**

- **Diagram Layout**

- **BDD/IBD Refresher**

- **Binding Connectors**

PAR Diagrams

- Display instances of types that exist in a particular configuration of the Block that you defined in a BDD.

- IBDs provide an internal view of a block's structure by displaying:
  - Elements of Usage owned by the block named in the header of the diagram
    - Mainly the Part Properties, Reference Properties, and sometimes Ports
  - How those elements of usage are connected to each other
    - Displayed by using Connectors
  - The services that are provided and required across the connections
    - Displayed by using Standard Ports
  - The types of matter, energy, or data that flow across those connections
    - Displayed by using Flow Ports and/or Item Flows

- NOTE:
  - IBDs <u>CANNOT</u> display elements of definition (blocks or other)

PAR Diagrams 101

- Refresher of Constraint Blocks: "Special kind of block that encapsulates a constraint expression: the equation or inequality you need to model"

- PARs allow you to impose a fixed mathematical relationship on a block's value properties

- Allows you to:
  - Specify assertions about valid system values within an operational system (and detect exceptional conditions)
  - Use the blocks in your system model to provide the inputs for (and capture the outputs of) engineering analyses and simulations

Purpose of PAR Diagrams

- diagramKind = ibd
- modelElementType = block

diagramKind [modelElementType] modelElementName [diagramName]

ibd [block] modelElementName [diagramName]

PAR Purpose

- Diagram Purposes:
  - Display the bindings between constraint parameters in different constraint expressions to create a composite system of equations (or inequalities)
  - Display the bindings between constraint parameters and value properties to apply a constraint expression to a block

PAR Diagram Layout

- Remember from BDDs that a Block can own 5 kinds of structural features:
  - Features come in two varieties **Structural** and **Behavioral**
  - 5 Kinds of structural features (aka **properties**)
    - Part properties
    - Reference properties
    - Value properties
    - Constraint properties
    - Ports
- IBDs generally show three of those 5 kinds of features:
  - Part Properties
  - Reference Properties
  - Ports
- Note: the other two kinds (Value and Constraint Properties) are shown on Parametric Diagrams!

Key Takeaway #1: PAR Diagram Layout

- Diagram Kind: "par" is a Parametric Diagram
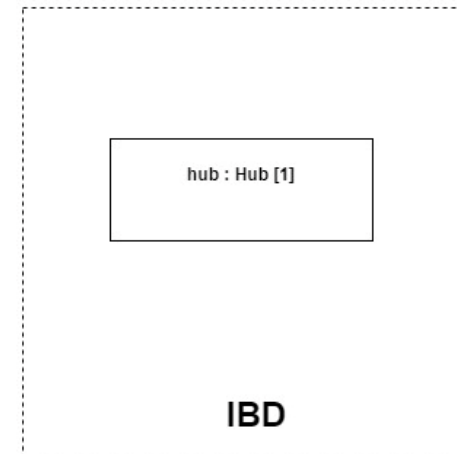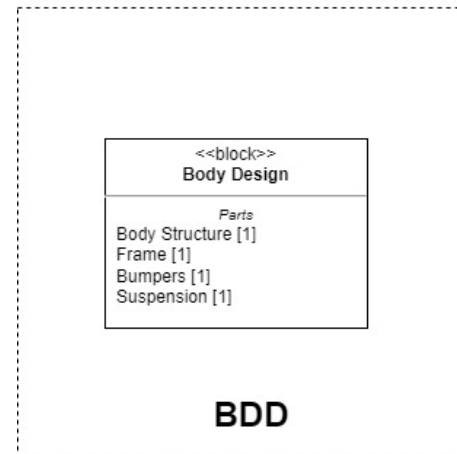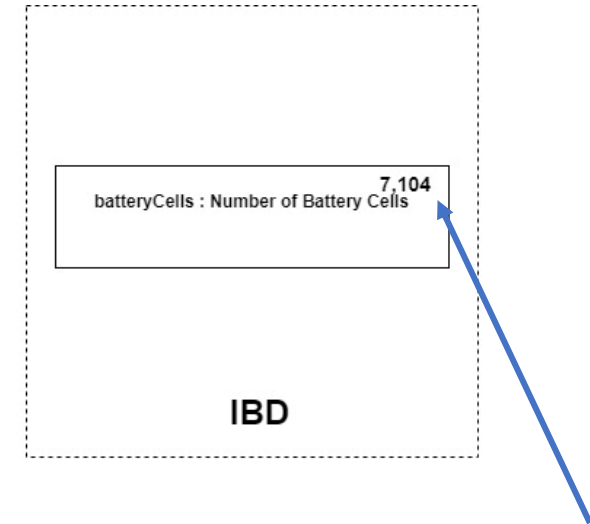- Model Element Type: either [block] or [constraintBlock]

Constraint Properties
Lenny - "round-angle"
(rounded corner
rectangle)
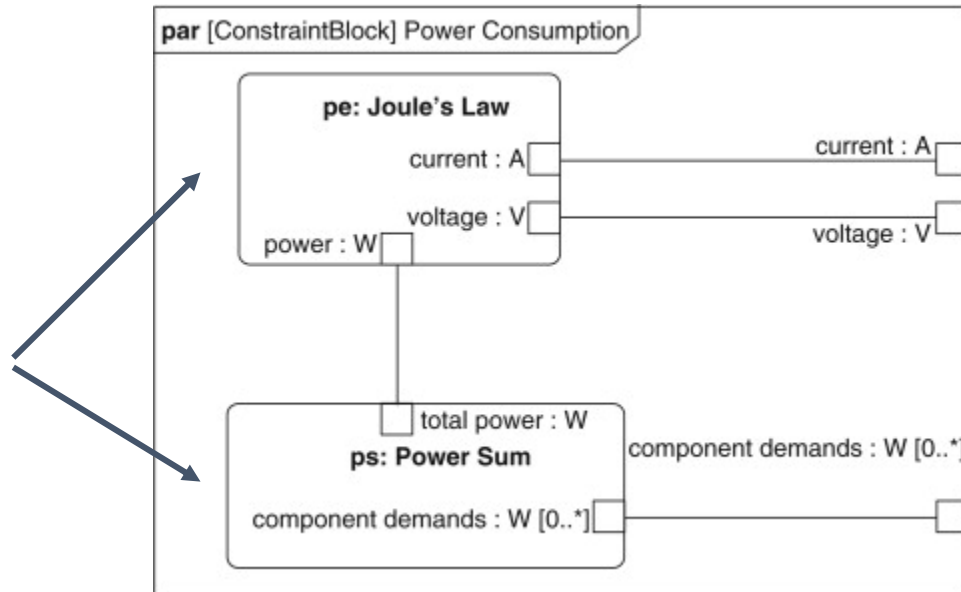
BDD/IBD Refresher

- Graphical Notation:
  - Rectangle with a solid line border
- Namestring:
  - <part name> : <type> [<multiplicity>]
  - Default multiplicity when not shown = 1
- Note: It is an option to display multiplicity either at the end of the namestring or in the upper right-hand corner of the rectangle
- Remember:
  - Part property means a thing (block) that is internal to the block that owns the part property

7,104
batteryCells : Number of Battery Cells

IBD

<<block>>
Body Design

Parts
Body Structure [1]
Frame [1]
Bumpers [1]
Suspension [1]

BDD

hub : Hub [1]

IBD

Key Takeaway #2: BDD/IBD Refresher

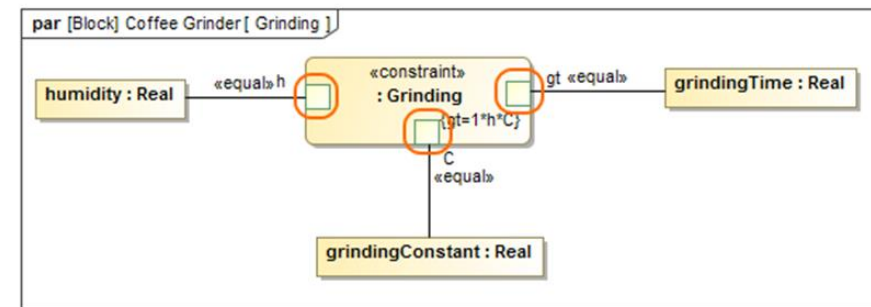- **Constraint Property**

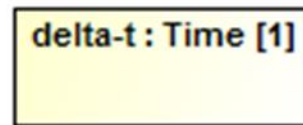- Displayed as round-angle on PAR

- Type must be constraint block
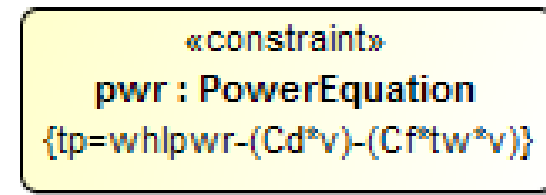
▼ Constraint Parameter

- Formal term for variable appearing in constraint expression

- Small square attached to the boundary on the inside of a constraint property

- Typed by Value Types

▼ Value property

- Usage of a value type in context of an owning block

- Supply values to constraint parameters

«constraint»
pwr : PowerEquation
{tp=whlpwr-(Cd*v)-(Cf*tw*v)}

par [Block] Coffee Grinder [Grinding]

humidity : Real   «equal» h   «constraint» : Grinding   gt «equal»   grindingTime : Real

{gt=1*h*C}

C
«equal»

grindingConstant : Real

delta-t : Time [1]

Binding Connectors

- Connector IBDs
  - SysML defines default multiplicities of 1 on each end of a connector. These multiplicities may be assumed if not shown on a diagram. To avoid confusion, any multiplicity other than the default should always be shown on a diagram.

EXAMPLE

*Per OMG Standards

Key Takeaway #3 : Binding Connectors

- Can appear ONLY on a PAR diagram
- Convey no notion of direction
- One of two bound elements must be constraint parameter
- Other element must be a value property or another constraint parameter
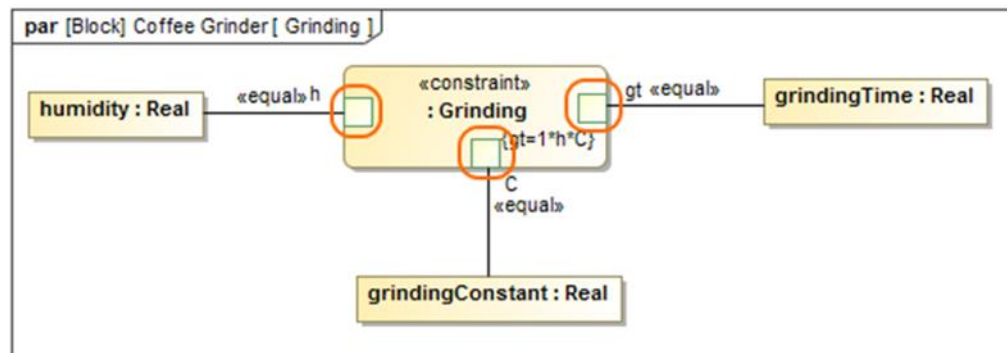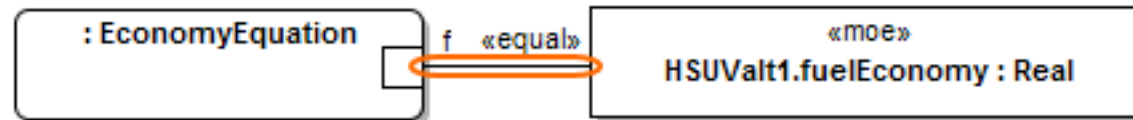
Questions

References

- Additional information can be obtained by reviewing:
  - SysML Distilled (Delligatti)
    - Chapter 4: Internal Block Diagrams
  - A Practical Guide to SysML (Friedenthal)
    - Chapter 7: Modeling Structure with Blocks
      - The Block section covers both BDDs and IBDs
  - OMG SysML Spec v1.2
    - Section 8: Blocks
      - The Block section covers both BDDs and IBDs
    - Section 9: Ports and Flows

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Summary

Review Questions

Question 1

- What model element can an IBD represent?
    - A. Reference Association
    - B. Part Property
    - C. Block
    - D. Value Type
    - E. Reference Property
    - F. Operation
    - G. Constraint Block
    - H. Connector
    - I. Value Property
    - J. Port

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Review Question N.PAR.1

- Which of the below items are possible model element types represented in a PAR diagram frame (choose all that apply):

  A. package
  B. stateMachine
  C. block
  D. interaction
  E. constraintBlock
  F. modelLibrary

Review Question N.PAR.1 (ANSWER in Green)

- Which of the below items are possible model element types represented in a PAR diagram frame (choose all that apply):

  A. package

  B. stateMachine

  C. block

  D. interaction

  E. constraintBlock

  F. modelLibrary

  See SysML Distillied Section 9.4

Question 2

- On an IBD, ___ appear as solid boundary rectangles and ___ appear as dashed boundary rectangles.

    A.   Reference Properties, Reference Associations
    B.   Part Properties, Reference Properties
    C.   Part Properties, Value Types
    D.   Reference Properties, Constraint Blocks

Review Question N.PAR.2

- Which types of SysML diagrams will never contain binding connectors (choose all that apply):

    A. ibd
    B. bdd
    C. par
    D. uc
    E. act
    F. pkg

Review Question N.PAR.2 (ANSWER in Green)

- Which types of SysML diagrams cannot contain binding connectors (choose all that apply):

A. ibd

B. bdd

C. par

D. uc

E. act

F. pkg

See SysML Distillied Section 9.8

Question 3

- All solid lines on an IBD are:
    - A.   Associations
    - B.   Constraints
    - C.   Connectors
    - D.   Reference Associations
    - E.   Sometimes they are Connectors (when they are not typed) and sometimes they are associations (when they are typed)

Review Question N.PAR.3

- What two elements are binded together in a parametric diagram:
    - A. Constraint Parameters & Constraint Blocks
    - B. Constraint Parameters & Value Types
    - C. Constraint Parameters & Value Properties
    - D. Constraint Properties & Value Types
    - E. Constraint Properties & Value Properties

Review Question N.PAR.3 (ANSWER in Green)

- What two elements are binded together in a parametric diagram:
    A. Constraint Parameters & Constraint Blocks
    B. Constraint Parameters & Value Types
    C. Constraint Parameters & Value Properties
    D. Constraint Properties & Value Types
    E. Constraint Properties & Value Properties
    See SysML Distillied Section 9.3