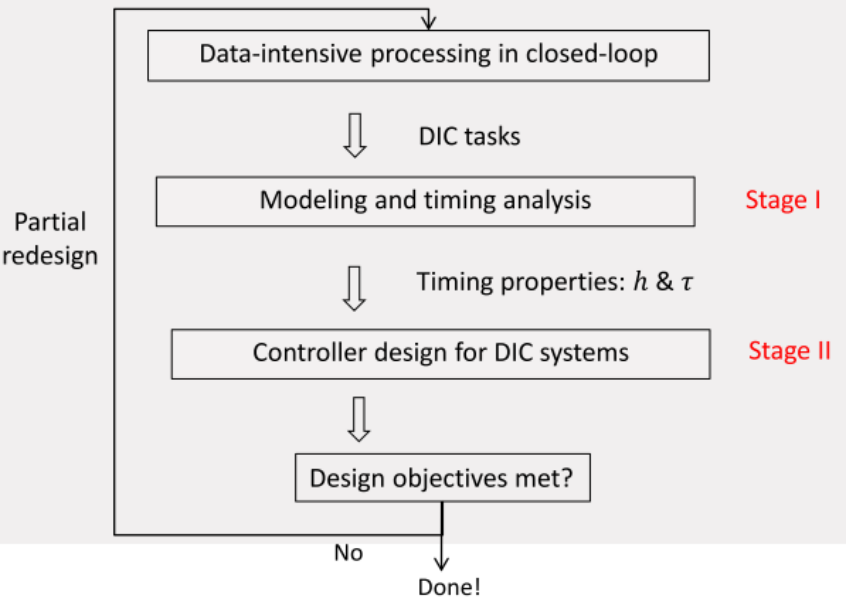
2_1_Introduction

1. Conceptions

Sampling Period:

The **sampling period** is the time between the start of two consecutive sensing tasks

2. Design Framework



3. Example of DIC Systems： IBC Systems

- Camera framerate is much higher than the rate at which frames are processed; **several frames are not processed**

Notations:

- Sensing, computing and actuating tasks have WCETs τ_s, τ_c, τ_a, and we have $\tau_s \gg \tau_c + \tau_a$
- Total worst-case execution time of the task $\tau_t = \tau_s + \tau_c + \tau_a$
- The sensor-to-actuator delay $\tau = \lceil \frac{\tau_t}{f_h} \rceil f_h$

4. Timed Synchronous Dataflow (SDF) Models

Definition: Dataflow

Dataflow is an abstract mathematical model that can be used to model repetitive deterministic operations on streams of products, or streams of data items, often including the resources on which they are realized

Definition: Timed Dataflow Graph

A timed dataflow graph consists of

- a finite set A of **Actors**;
- firing **durations** $e : A \to \mathbb{R}_{\geq 0}$
- a finite set $C \subseteq A \times \mathbb{N} \times A$ of **channels**;
- a finite set I of **inputs**, with input dependencies $dI : I \to A$
  a finite set O of **outputs**, with output dependencies $dO : O \to A$

Actors

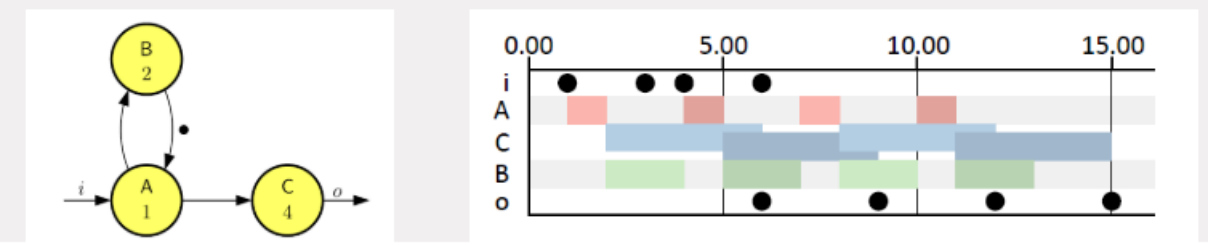
- **Actors** represent the **activities** in the model.
- An actor can **fire**, which means that it executes its activity. Actors can fire repetitively and indefinitely, unless there are constraints that prevent it;

Channels and Tokens

- Arrows between actors represent the **channels**
- A initial token can be used to prevent cyclic dependency

Graph Execution

All actor firings **start as soon as allowed** by the constraints



Multi-Rate Model

- In a multi-rate dataflow graph, actor firings may produce and/or consume multiple tokens with every firing.
- This rate must however be constant
- The number $c \in \mathbb{N}, c > 0$ of tokens it consumes from an input channel is called the **consumption rate**;
- The number $c \in \mathbb{N}, c > 0$ of tokens it produces is called the **production rate**;

Schedule

- A **schedule** for a dataflow graph is a function $\sigma : A \times \mathbb{N} \to \mathbb{R}$ that assigns starting times to the firings of actors of A
- $\sigma(a, k)$ where a is the actor and k is the number of iteration
- In models without inputs, or in which actor firings do not depend on inputs, there may not be an earliest firing time. In those cases, we may **explicitly add an earliest firing time**, usually 0 for such firings
- For the example above, The first input is available at Time $1; \sigma(A, 0) = 1, \sigma(A, 1) = 4, \sigma(A, 2) = 7, \sigma(A, 3) = 10, \sigma(B, 0) = 2, \sigma(B, 1) = 5, \sigma(B, 2) = 8, \sigma(B, 3) = 11, \sigma(C, 0) = 2, \sigma(C, 1) = 5, \sigma(C, 2) = 8, \sigma(C, 3) = 11$,

Throughput

Definition: Throughput

Given a dataflow graph, an actor $a \in A$ and a schedule σ is defined for all $k \in \mathbb{N}$, the **throughput** of actor a in schedule σ is given by the following limit

$$\tau(\sigma, a) = \lim_{k \to \infty} \frac{k}{\sigma(a, k)}$$

otherwise, the throughput of a is not defined

- If σ is a periodic schedule with period μ, then the throughput of any actor, if it fires infinitely often, is equal to $\frac{1}{\mu}$

Latency

Definition: Latency

The **latency** $L(\sigma, i, o)$ is equal to the maximum distance between an input and the corresponding output

- In the example above, the $L(\sigma, i, o) = 15 - 6 = 9$

Summary

- Data-Intensive Control Task: Data intensive
  - Example: IBC system $\tau_s >> \tau_a + \tau_c$
- Modelling DIC:
  - SDF model