nano-tera.ch
swiss scientific initiative in health / security / environment systems

UltrasoundToGo RTD 2013

FNSNF

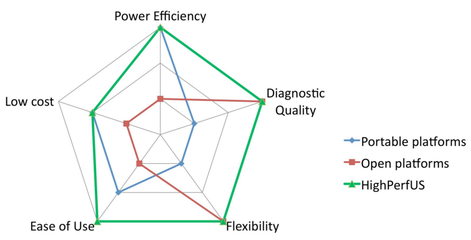
Modeling of Reconfigurable Pipelines for QoS on Medical Ultrasonic Applications.

Stefanos Skalistis, Alena Simalatsar
EPFL - Rigorous System Design Laboratory

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

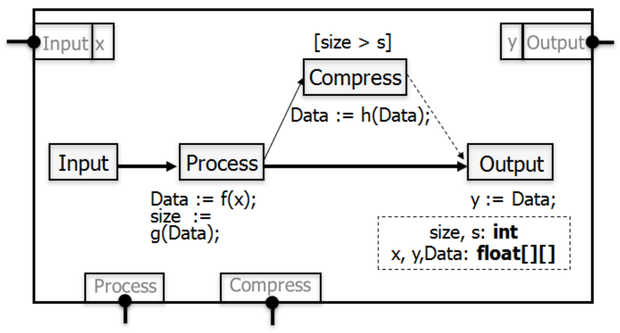
Motivation

Ultrasonic imaging is widely used in medicine as a diagnostic technique to provide static images (e.g., B-mode) and dynamic changes (e.g., based on Doppler effect). All these applications require high quality of images produced in real-time. Often ultrasonic devices are used in trauma and first aid cases as well as for remote diagnosis. The motivation of this work is to provide means for building a portable medical system that can be battery-operated and thus be used in situations where traditional ultrasound systems can not be employed such as medical emergencies and developing countries/areas where energy availability can be an issue.

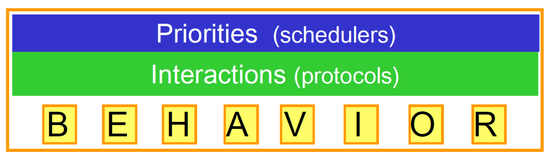


Synchronous BIP

The BIP framework allows modeling of systems as composition of atomic components by encompassing three layers.

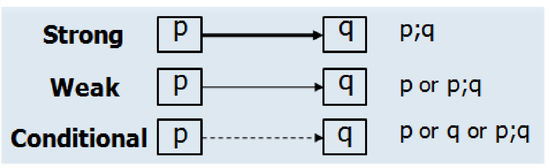


In synchronous BIP, the use of the BIP engine is not necessary. Modal flow components define three kind of causal dependencies between ports.



Well-triggered modal flow graphs [1] are used to model synchronous components and guarantee by construction:

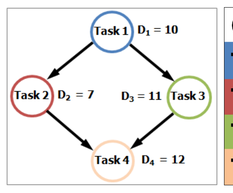
- **Deadlock-freedom**
- **Confluence**



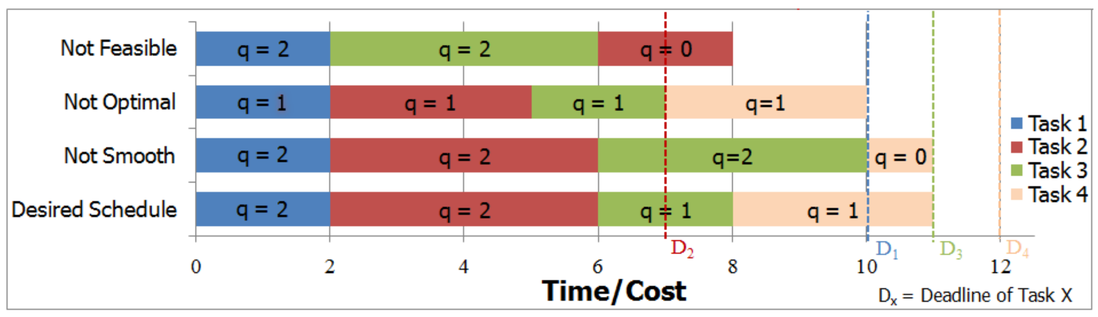
Quality of Service (QoS)

Medical ultrasonic systems require both critical and best-effort practices [2]. Fine grain QoS management allows the run-time adaptation of the overall system behavior. The approach in [2] provides control over three main properties:

- **Feasibility:** no deadline is missed
- **Optimality:** best use of resources
- **Smoothness:** of quality levels



Cwc / Cav	q = 0	q = 1	q = 2
Task 1	1 / 1	3 / 1	4 / 2
Task 2	2 / 1	3 / 2	4 / 3
Task 3	3 / 2	3 / 2	4 / 3
Task 4	1 / 1	3 / 1	3 / 2



Case Study

There are several types of imaging applications that are based on ultrasound waves:

- A-mode
- B-mode (or 2D-mode)
- Doppler mode
- Harmonic mode
- etc. . .

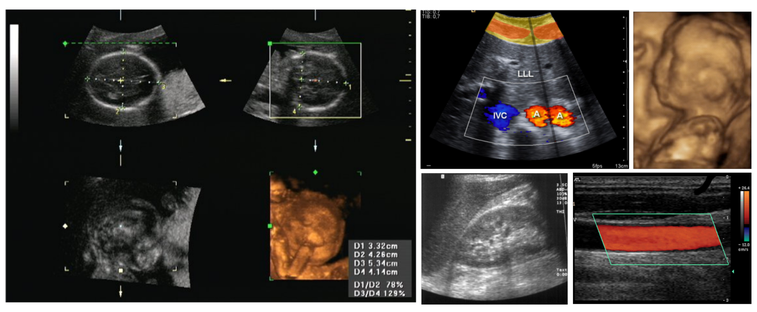
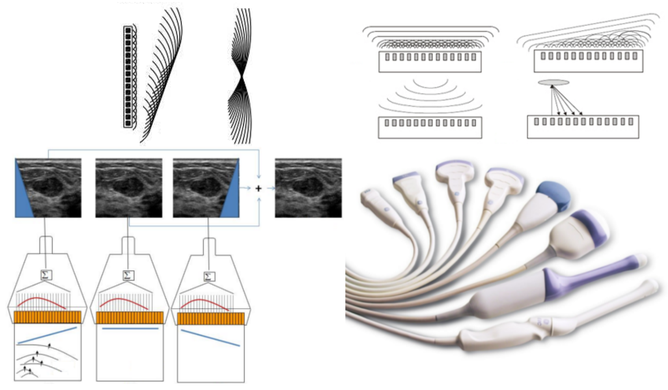


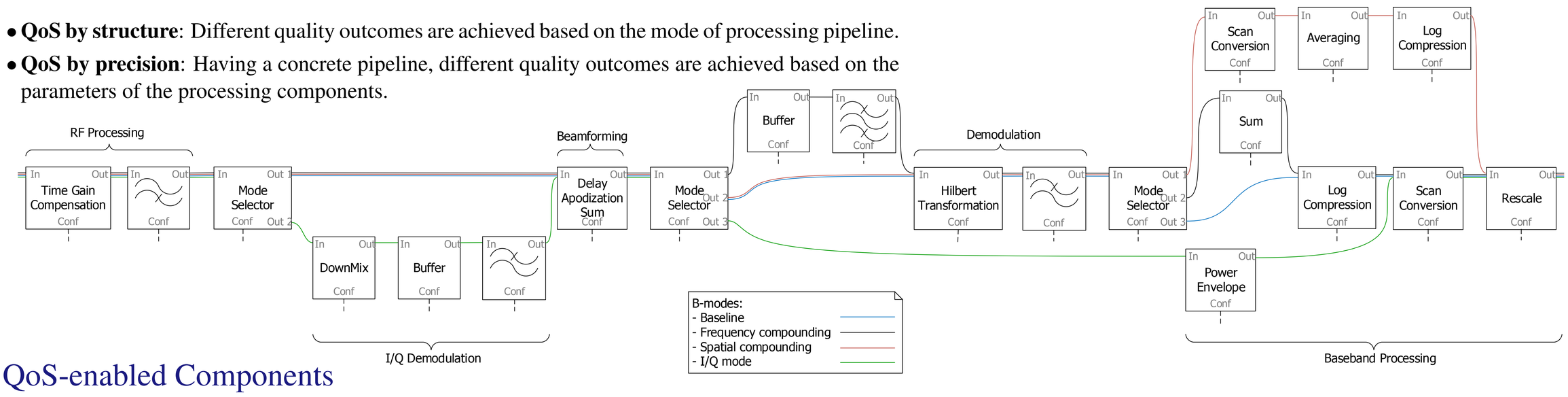
Image quality can be affected by:

- the processing mode
- the shape of the probe
- the type of the beam wave
- the angle of the beam
- etc. . .



Reconfigurable Multimedia Systems

- **QoS by structure**: Different quality outcomes are achieved based on the mode of processing pipeline.
- **QoS by precision**: Having a concrete pipeline, different quality outcomes are achieved based on the parameters of the processing components.



QoS-enabled Components

To model reconfigurable multimedia systems we define the following well-triggered components:

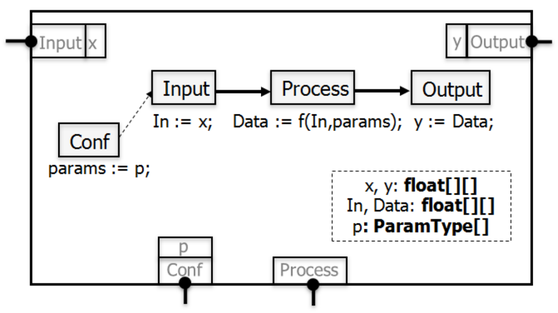


Figure 1: Processing component

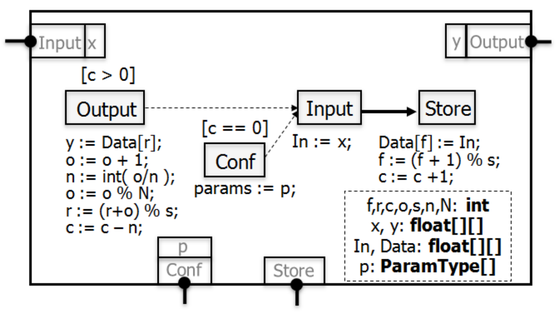


Figure 2: N-read Buffer component of size s

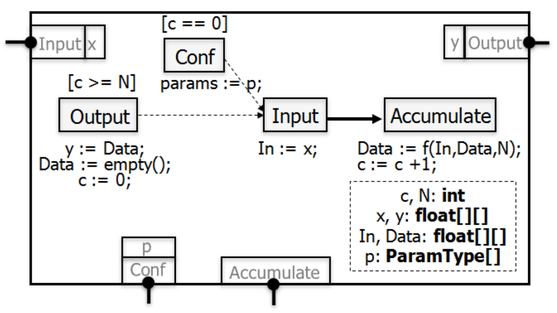


Figure 3: N-write Accumulator component

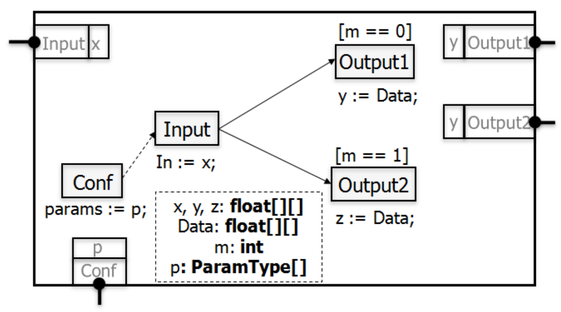


Figure 4: Mode-selector component

It is possible to model complex deadlock-free and confluent reconfigurable pipelines that can provide QoS by structure and support QoS by precision.

References

[1] Marius Dorel Bozga, Vassiliki Sfyrla, and Joseph Sifakis. Modeling synchronous systems in BIP. In *Proceedings of the Seventh ACM International Conference on Embedded Software*, EMSOFT '09, pages 77–86, New York, NY, USA, 2009. ACM.

[2] Jacques Combaz, Jean-Claude Fernandez, Thierry Lepley, and Joseph Sifakis. Qos control for optimality and safety. In *Proceedings of the 5th ACM international conference on Embedded software*, pages 90–99. ACM, 2005.