Formal Description of Multi-Touch Interactions

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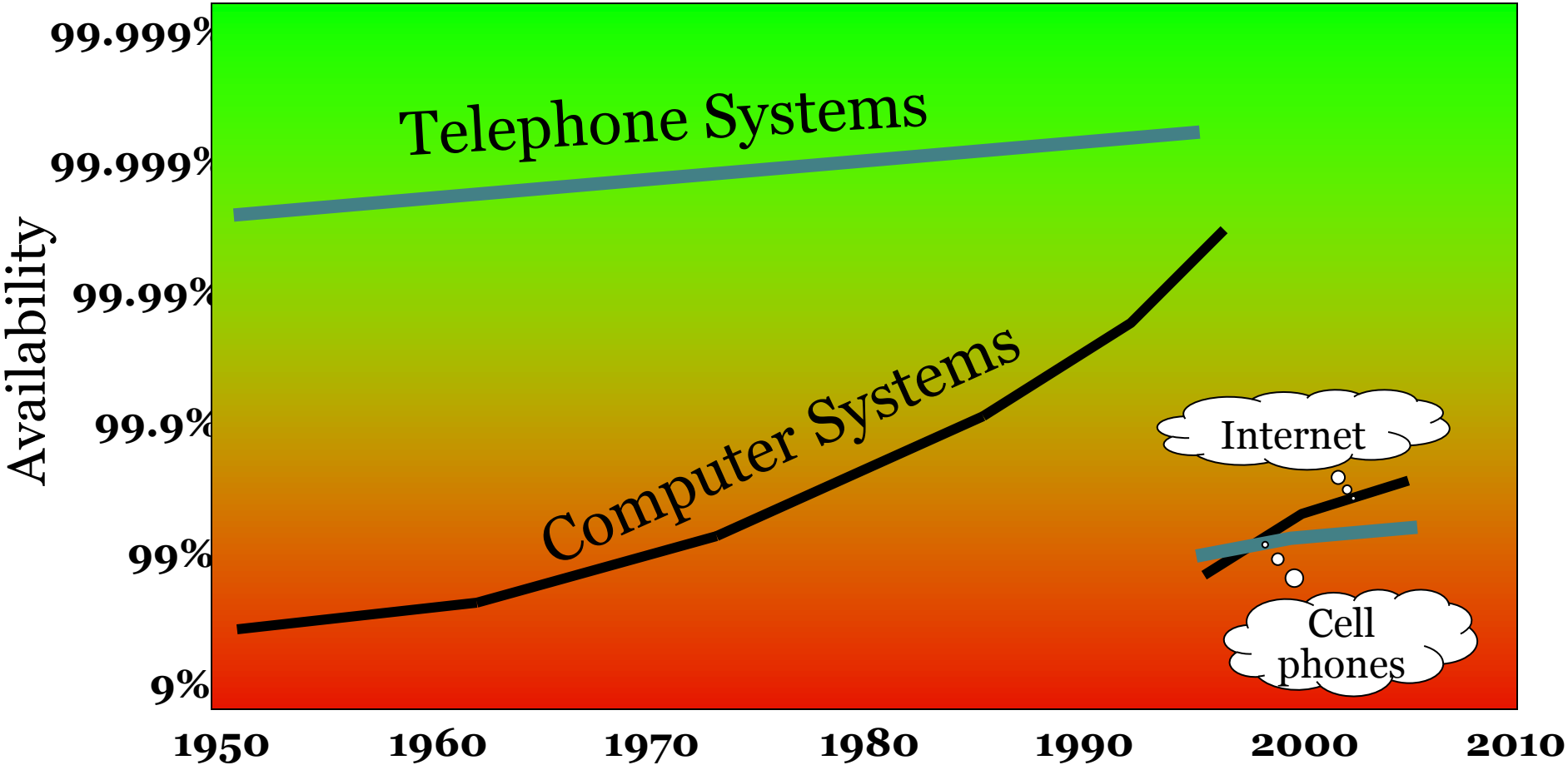
Context of this work

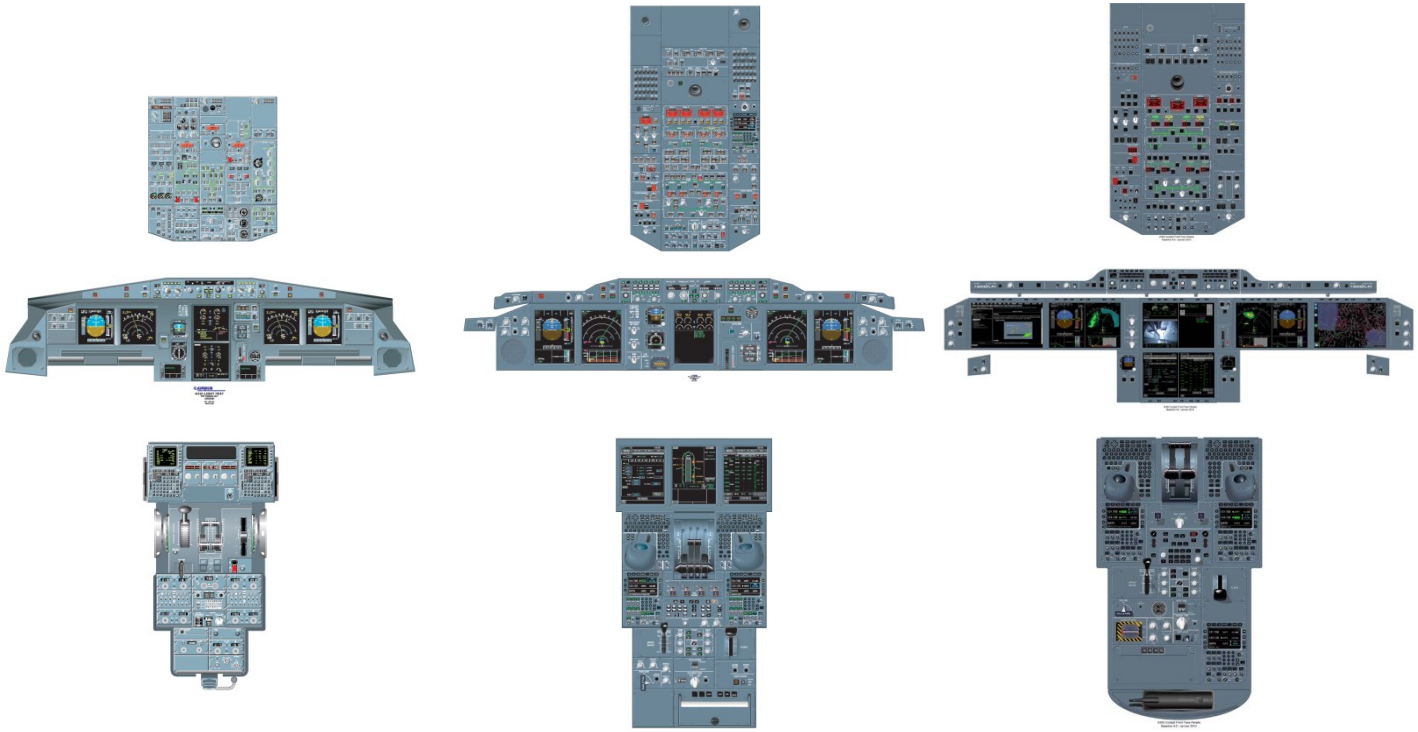
- The world is changing (in terms of interaction with computing device)
  - In our daily life
  - In the aeronautics area
  - In all the other areas
  - Step forward ? Step backward ? – FAA certification of iPAD for EFB

The Last 10 Years – J. Gray (Dep. In the internet area – High Dep Comp. Conf 2005)

- Things got better, then things got a lot worse!



Context of this work – the times they were a-changin’




2 LIFE VESTS

Context description – rationale for changes (already from ARINC 661 - 2000)

- More systems to manage,
- More complex systems,
  - Need for more command and control functionalities
  - Need for more monitoring capabilities
  - Need integration (concentration) of information

Increase Pilots-CDS interactions bandwidth

- Available space limited cockpits
  - Manage the command and control surfaces
- Evolvability of the systems
  - Need for more upgradable equipment's

Evolution of the HCI concepts

Bringing Tactile Interactions in the Cockpit

- Rationale
  - Bandwidth improvement between pilots and systems
  - Wider integration of input and output
  - Space management (input integrated in output)
- Reduction of constraints
  - Technology getting mature (is it enough for cockpit integration?) for studies
  - Widespread use and basic knowledge in the user population – reduced training / differential training

Current Situation

- Low hanging fruits already been collected
- Foundations identified many years ago
- Refinement and deeper understanding over the years

Requitements for notations - State of the art UIDL

- Dynamic instantiation
  - Fingers are detected as users touch the screen
  - -> Need to instantiate and remove their behavior, link all possible associated events dynamically
  - Their value need to be connected to the models evolution
- Fingers' clustering
  - Being able to group, ungroup and regroup fingers that are belonging to the same interaction technique
- Multimodal interactions
  - Full concurrency
  - Quantitative time
- Reconfigurability (in case of failures)
- Scalability
- Verify-ability

Notations - State of the art

		Constraint		Code Based			Flow Based					State Based				Petri Nets			
		ConstraintJS [43]	Squeak [11]	XISL [24]	UsiXml [32]	GeForMT [23]	GWUIMS [39]	Tatsukawa [44]	Marigold [45]	Wizz'ed [16]	ICON [14]	Swinstate [3]	Hierarchical [9]	NiMMiT [13]	Proton++ [26]	Hinckley [20]	MIML [31]	ICO [this article]	CPN [21]
Data Description		Some	Some	Some	Some	Some	Yes	Yes	Yes	Yes	Yes		Some	Yes	Some		Yes	Yes	Yes
State Representation		Some							Yes			Some	Some	Yes		Yes	Yes	Yes	Yes
Event Representation		Some	Some	Some	Some	Some	Some	Yes	Yes	Yes	Yes	Some	Some	Yes	Yes	Yes	Yes	Yes	Yes
Time	Qualitative between two consecutive model elements	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Quantitative between two consecutive model elements	Yes				Yes									Some			Yes	Yes
	Quantitative over non consecutive elements	Yes				Yes											Yes	Yes	Yes
Concurrent Behavior		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes		Yes	Yes	Yes
Multimodality: fusion of several modalities		Some	Some	Yes	Yes					Yes	Yes					Yes		Yes	
Analysis				Some					Some						Some			Some	Yes
Dynamic finger clustering		Some	Some															Yes	Yes
Capability to deal with multi-touch interactions	Implicit	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Explicit	Yes		Yes		Yes								Yes	Yes			Yes	

Yes Some Code No

The proposed approach

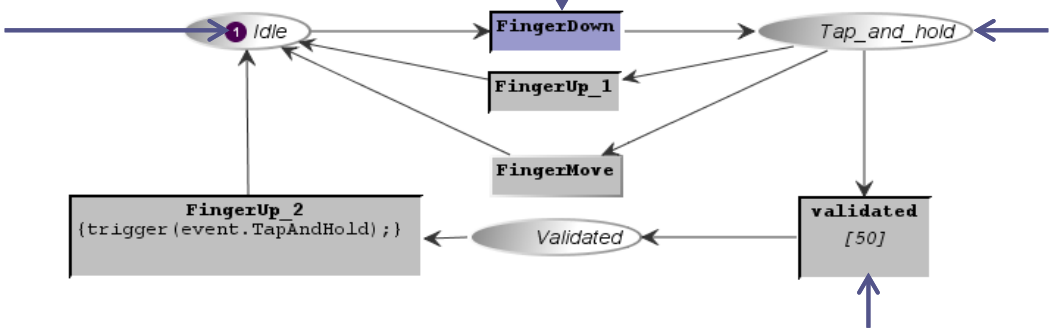
- A formal notation
  - State-based and event-based
  - Concurrent
  - Able to handling dynamic instantiation
- A dedicated tool for the notation
  - Models editing
  - Models simulations
  - Models verifications
- An architecture
  - To structure models
  - To go from hardware to software

The choice of notation and its associated framework

- ICO

Event-based transition

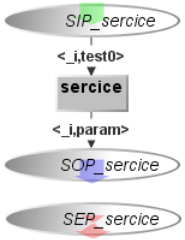
Token (interactive object)



Place

Timed transition

And services available:

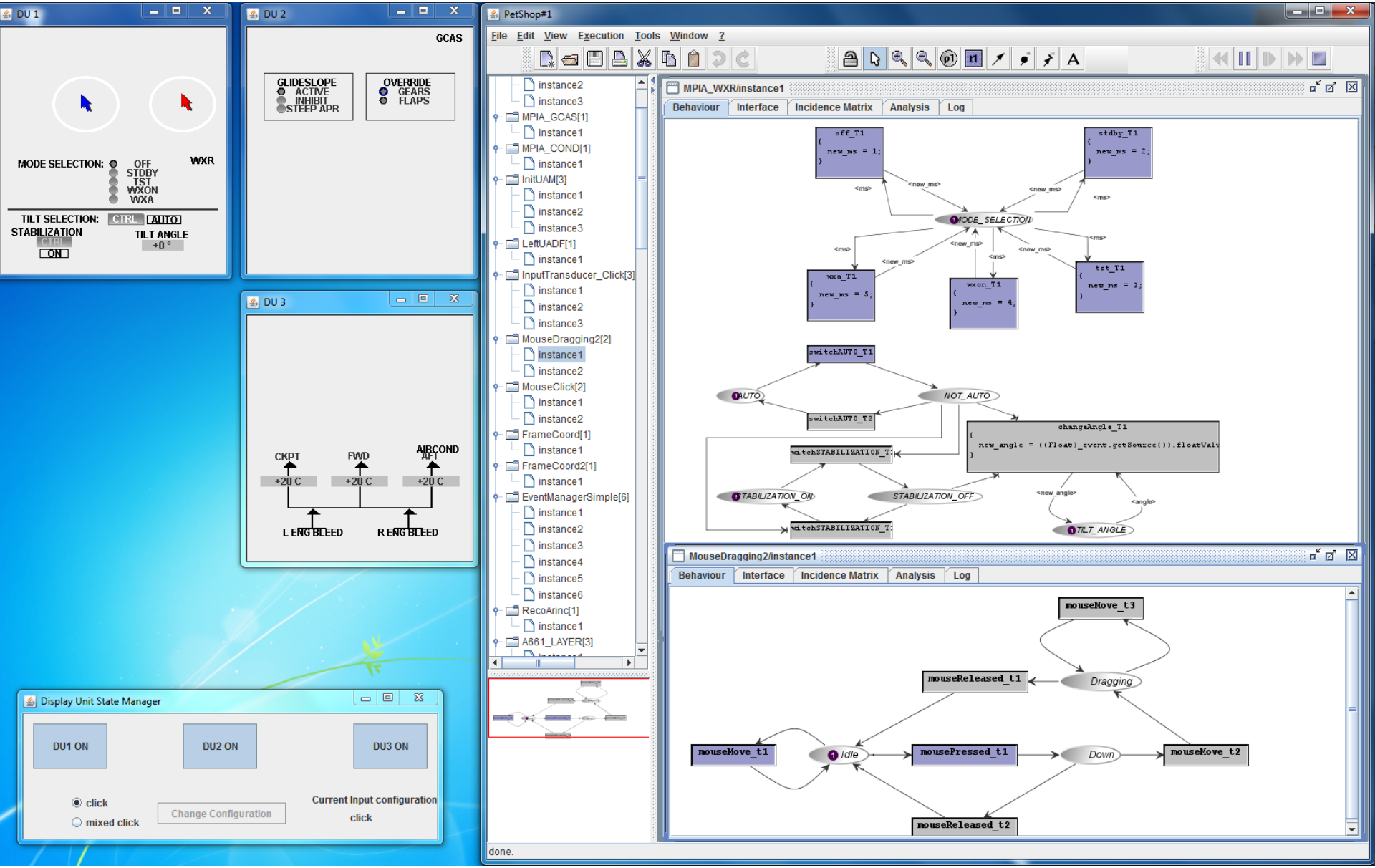


which corresponds

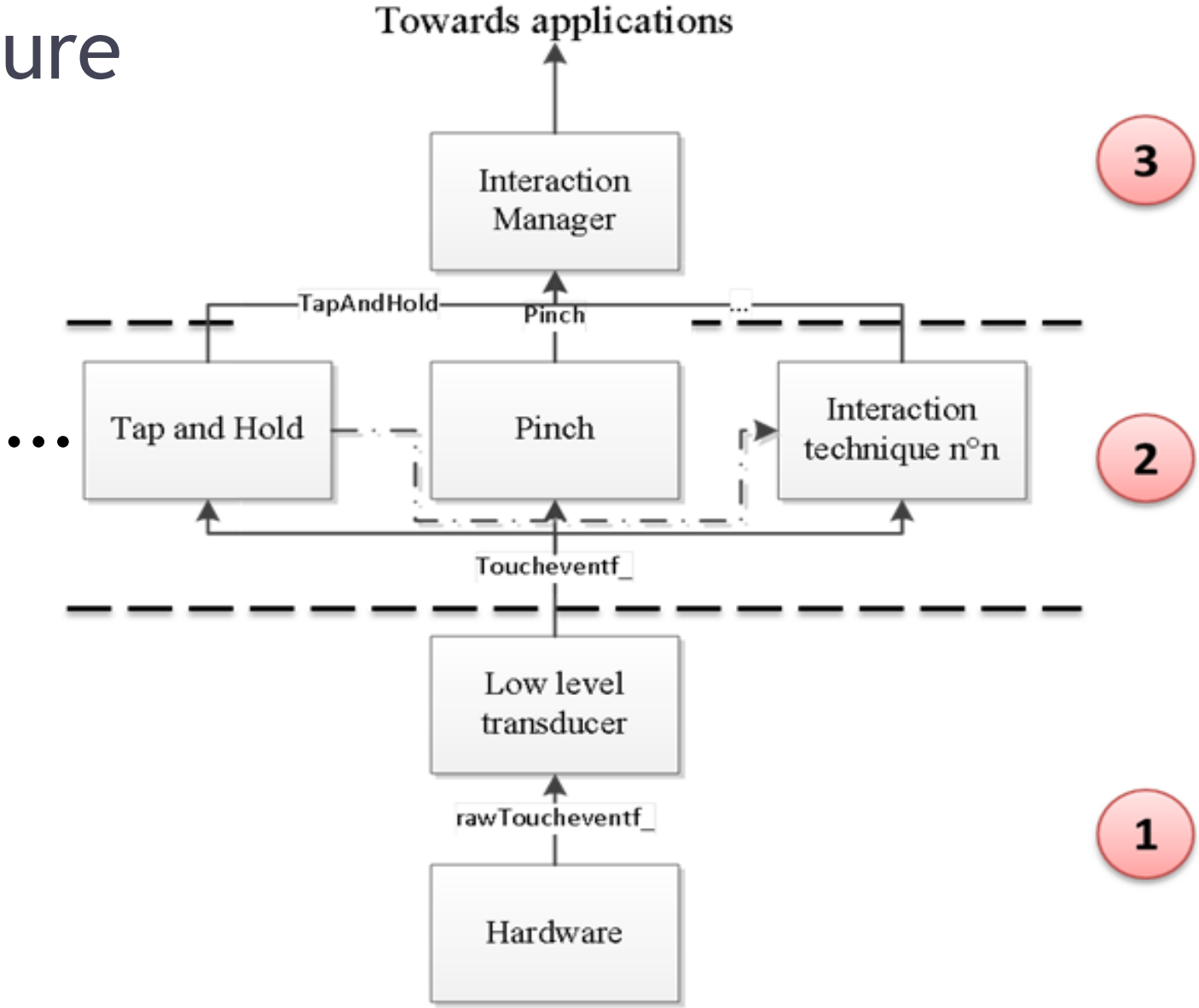
```
public interface netDemo {

    public int sercice(Object obj);
}
```

- PetShop environment edition, simulation, performance evaluation, testing and verification

The PetShop Environment

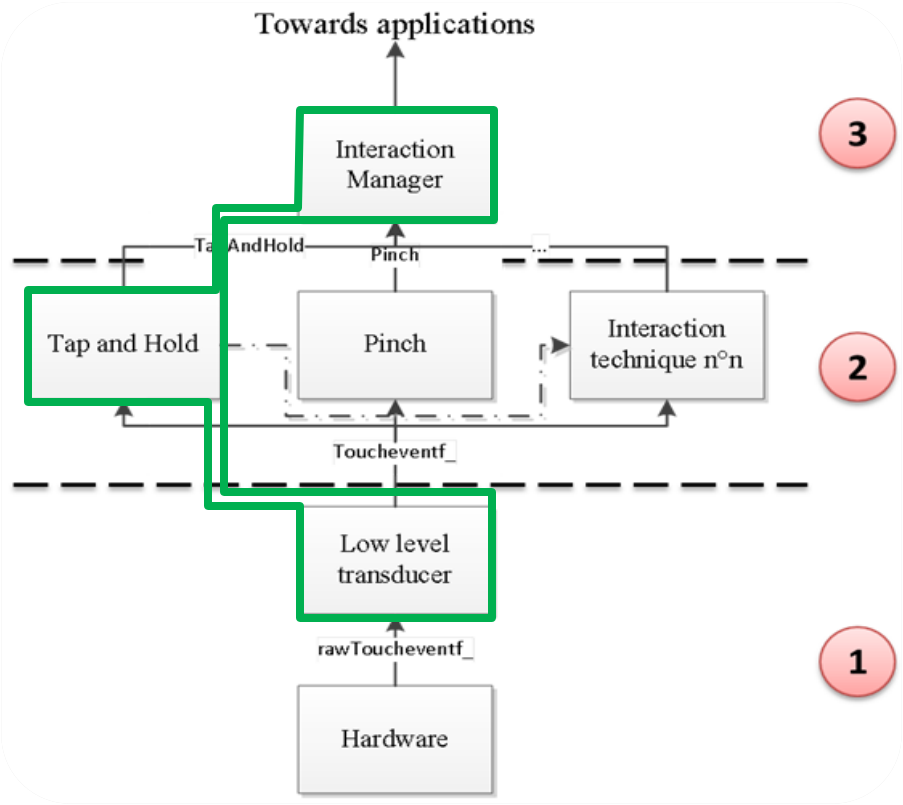


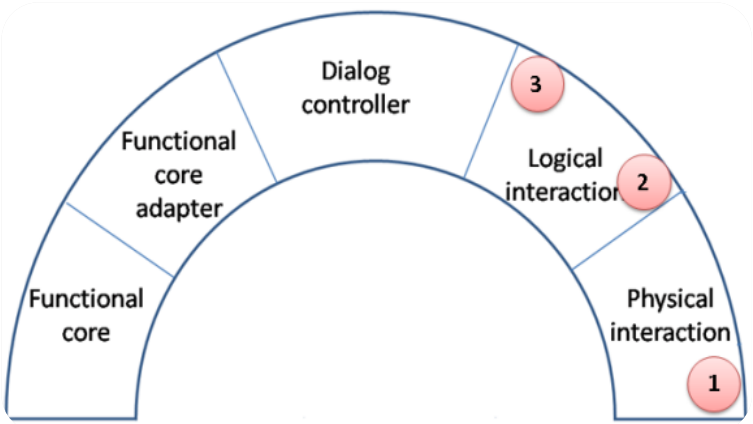
Multi-touch interaction system architecture



The need for an models' architecture

- Build on proven software architecture software that match our targeted properties
- To address the different event abstraction levels and a clean separation between dialog and presentation: ARCH

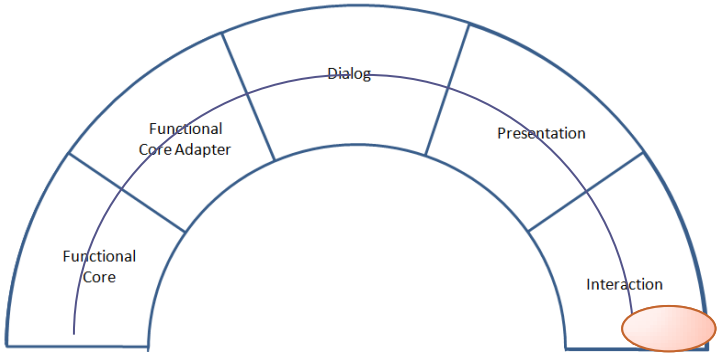




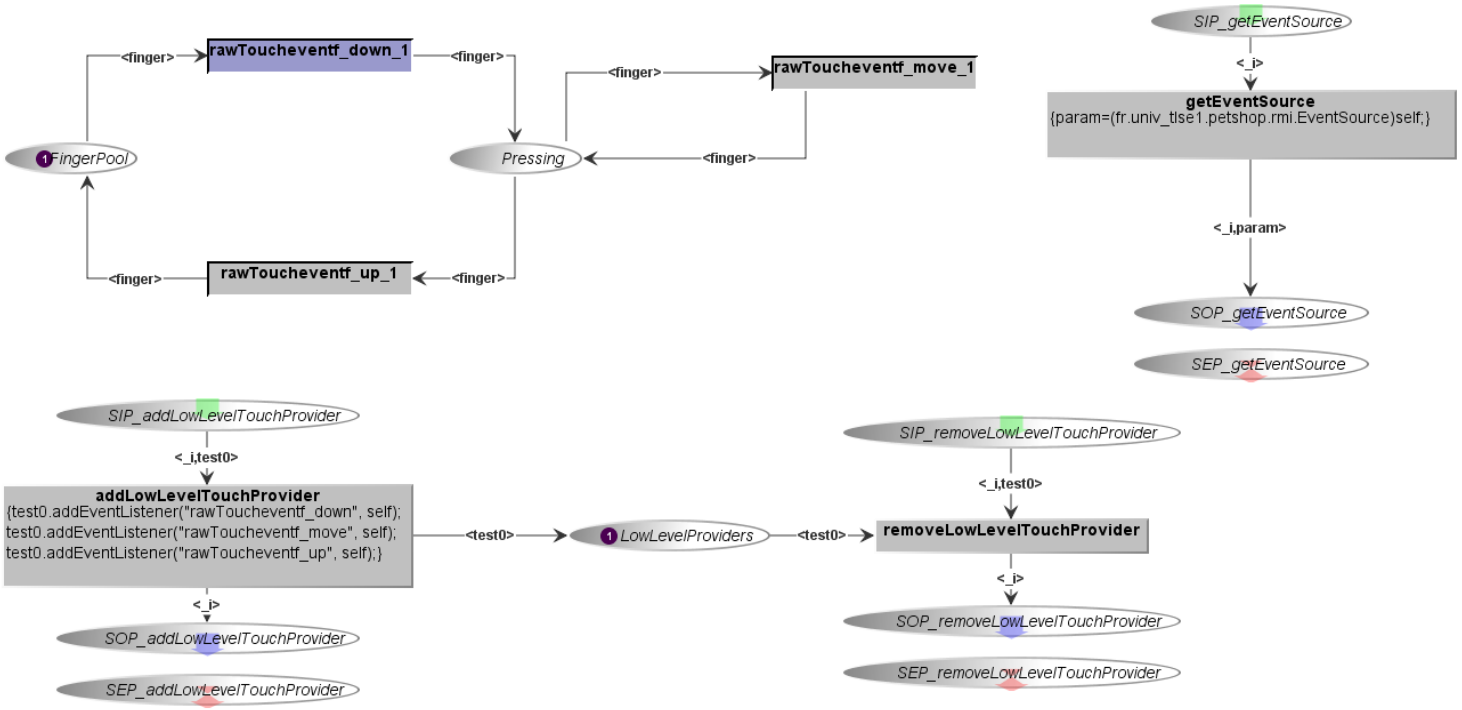
Bass, L., Pellegrino, R., Reed, S., Seacord, R., Sheppard, R., and Szezur, M. R. The Arch model: Seeheim revisited. Proc. of the User Interface Developpers' workshop. 91

Relationship with Hardware platform

- Low level transducer



The low level transducer receives the raw data events, and forwards then with the proper structure.



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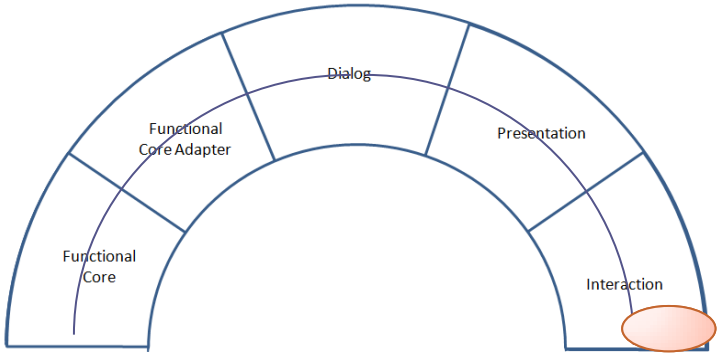

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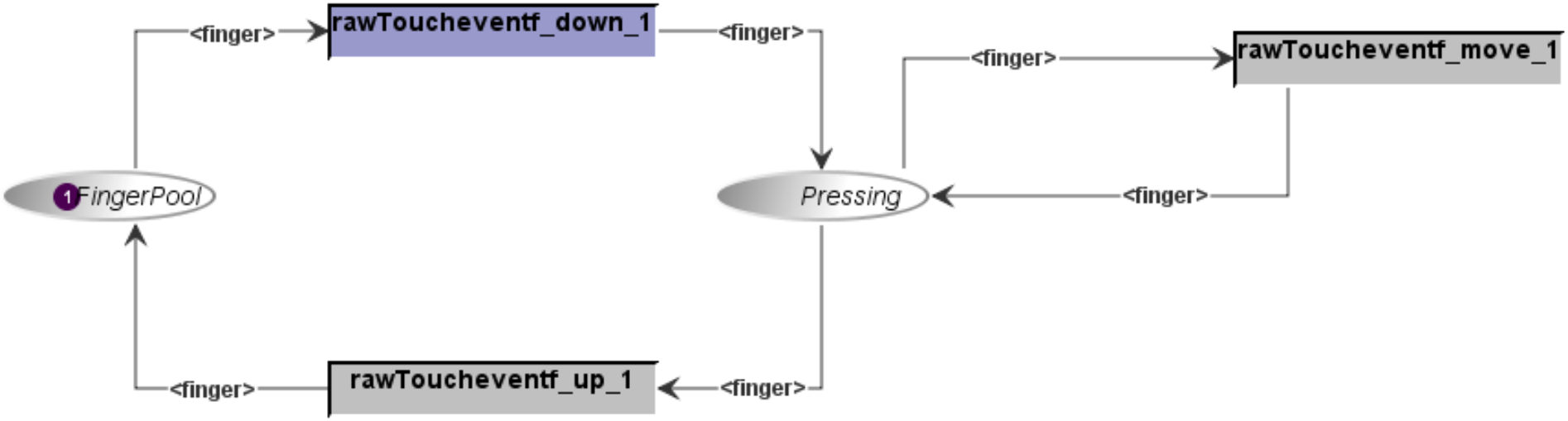

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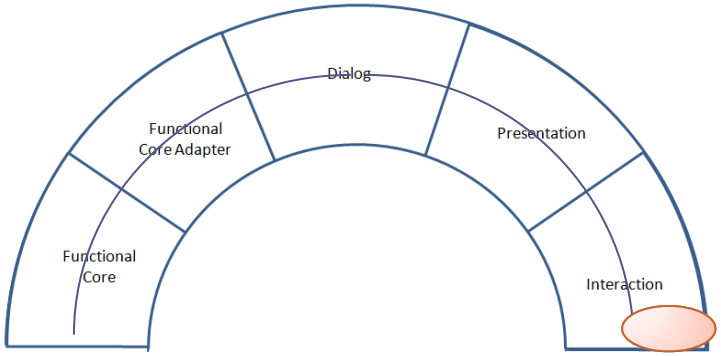

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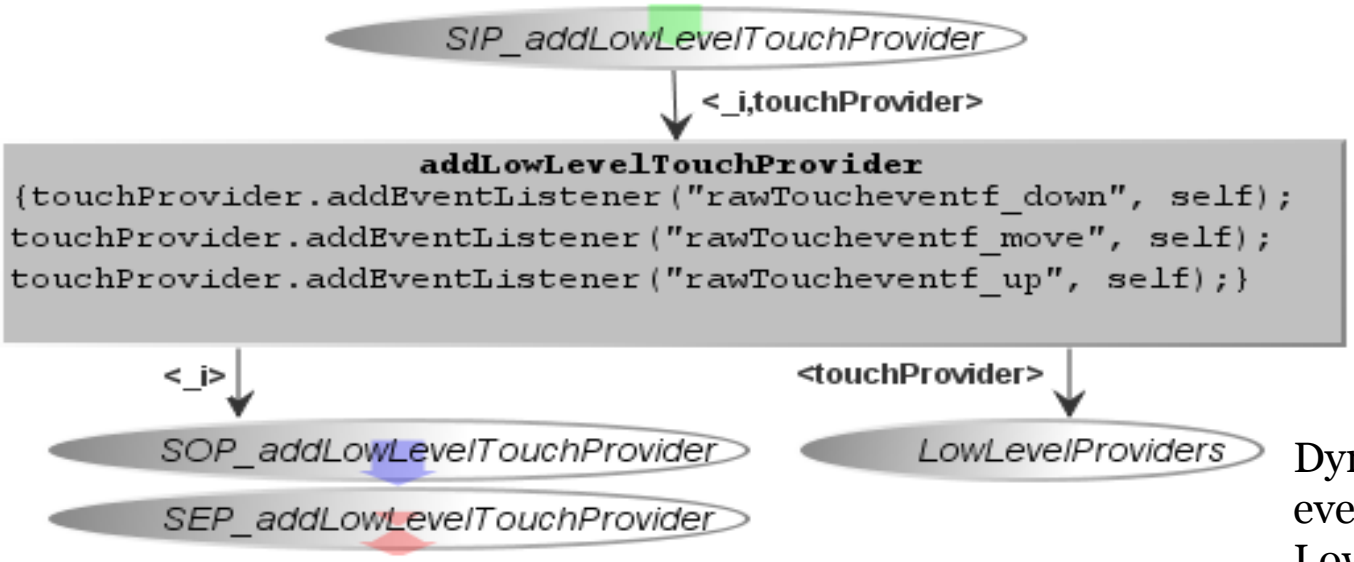
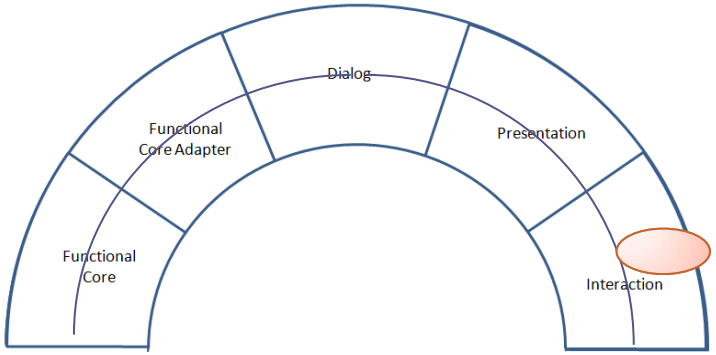


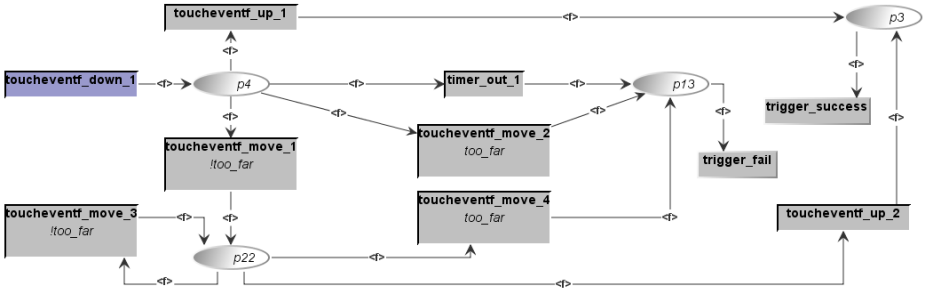
Dynamically registration to the event produced by the LowLevelTouchProvider.

Relationship with Hardware platform

- Elementary interaction techniques



TAP

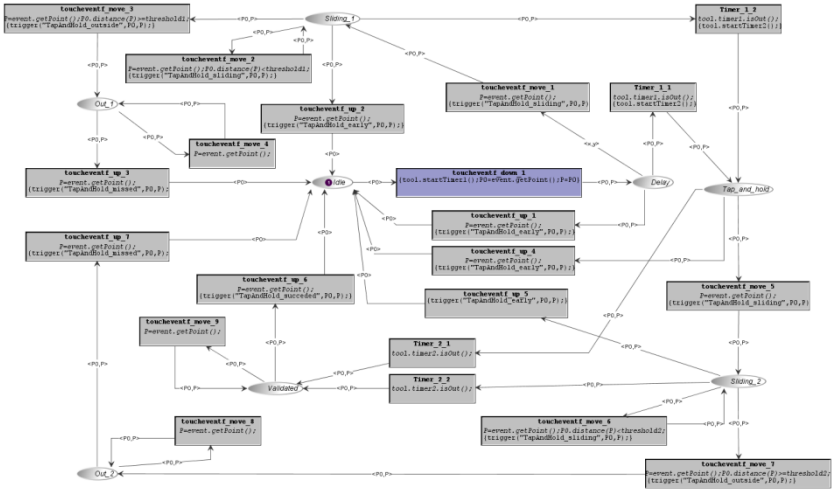


Theses models specify elementary multi-touch interactions:

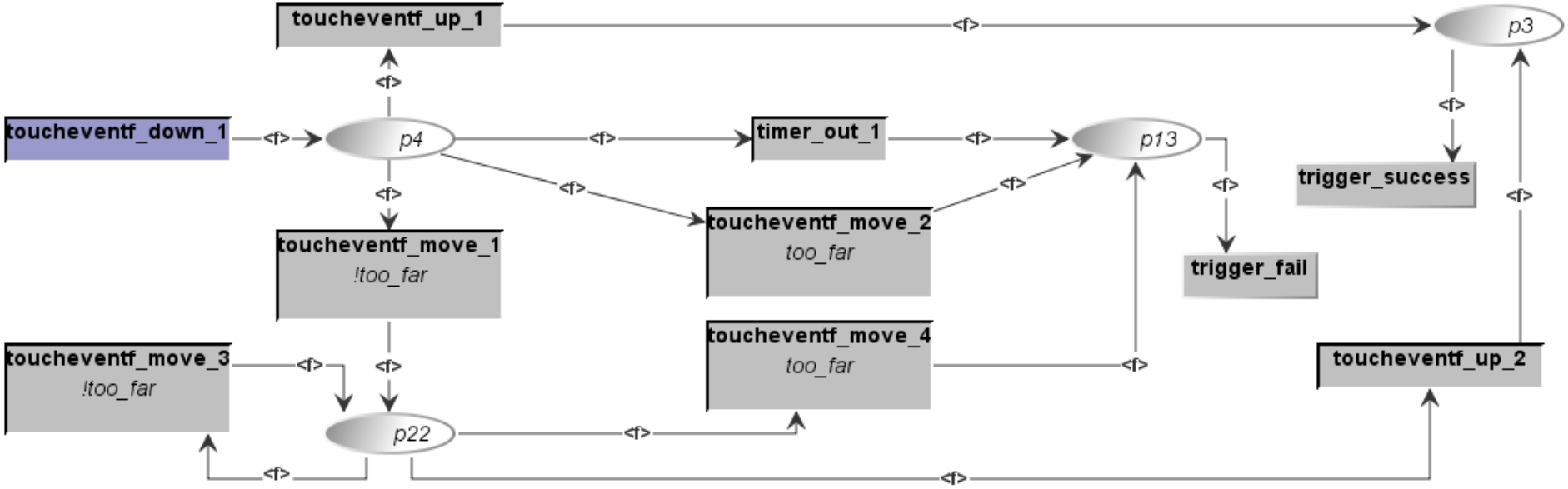
- Tap
- Tap and hold,
- … and zoom, pinch …

The models and independent and triggers the corresponding events which are listened by the Touch interaction manager

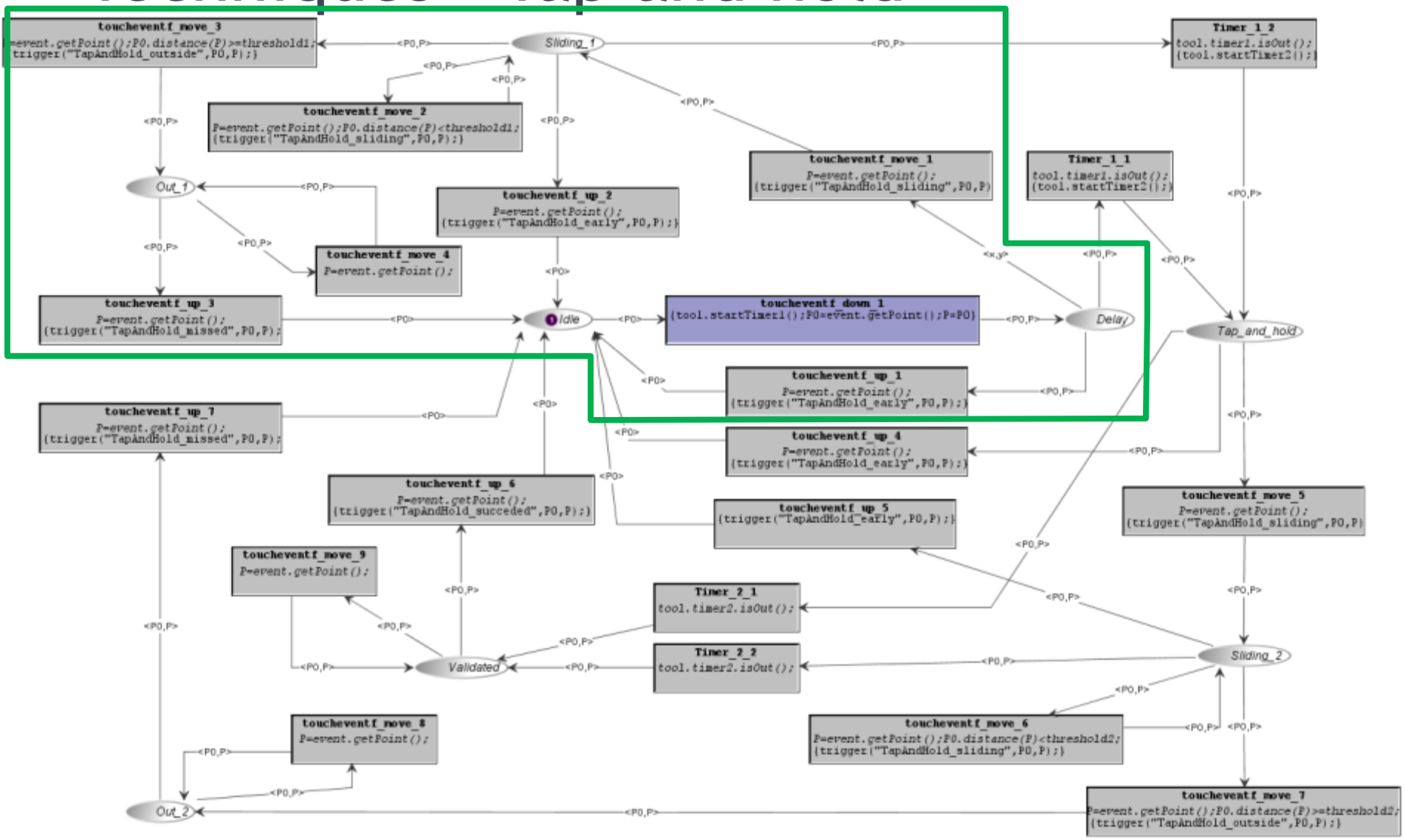
TAP and HOLD



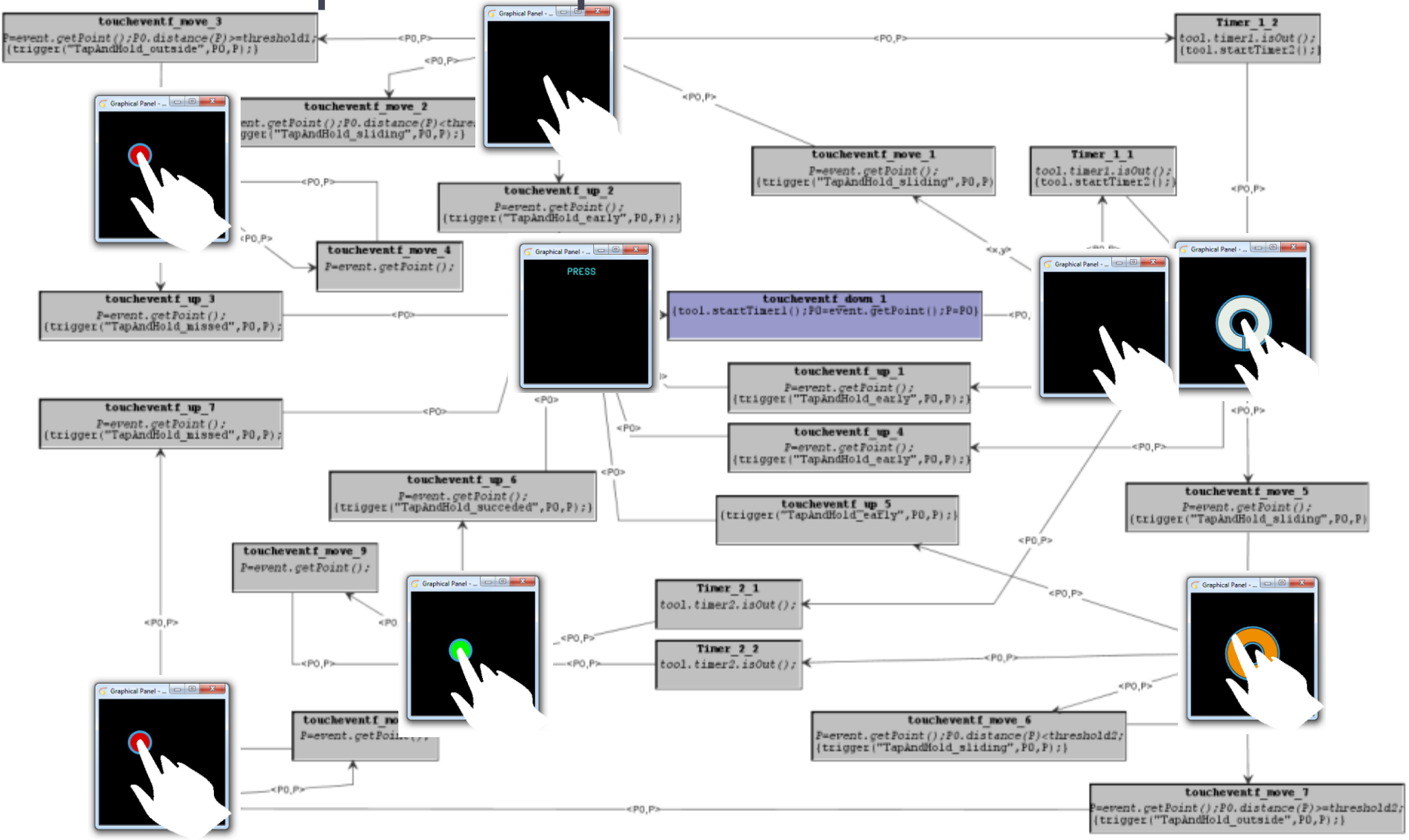
Formal Modeling of Interaction Techniques - Tap



Formal Modeling of Interaction Techniques – Tap and hold

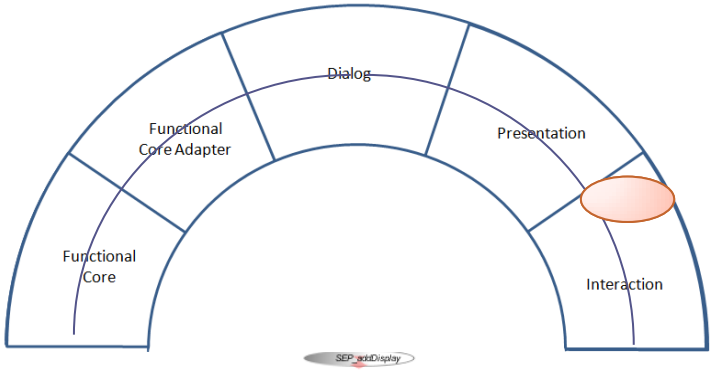


Formal Modeling of Interaction Techniques – Tap and hold

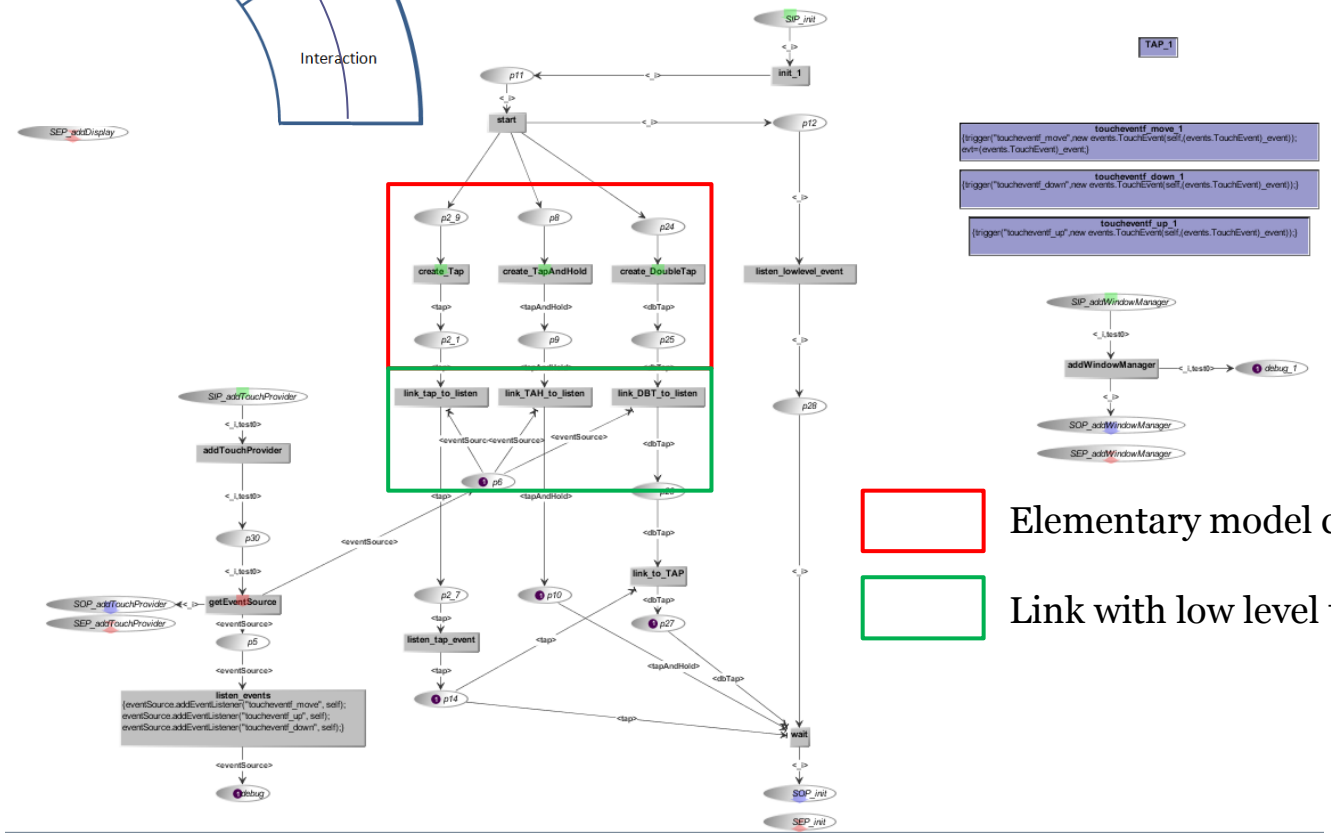


Relationship with Hardware platform

- Touch interaction manager



The presented model is currently in draft. It creates elementary interaction models and acts as a fusion/fission multimodal engine.



Conclusion

- A formal description technique for the description of touch-based interaction techniques
- Reasoning about models and properties
  (e.g. conservative and repetitive components)
- Software tool to support
  - description and execution of these interaction techniques
  - Tuning of interaction techniques
  - Integration within interactive applications
- A notation within a framework and within a process to model multi-touch interactions

Future Work

- Close work with people in charge of the defintion of touch interactions suitable with the context of use (vibration, light variation, stress level, …)
- Integrate precisely with rendering aspects (animations, …)
- Address more precisely gesture aspects (directions, speed, shapes, …)
- Experimental results and user studies
- Connection with work on fault-tolerance and dependability

Thank you very much
for your attention