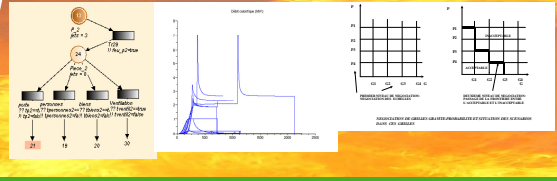


### 3.2 Stochastic computation and hybrid event modeling approach for global fire safety analysis (short version)

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**SCHEMA-S.I.**  
**Stochastic Computation and Hybrid Event Modeling Approach for Global Fire Safety Analysis**  
Application example on an hotel

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**Aim of the presentation**

- **Present a new modeling approach for fire safety analysis**
  - + Research work (CSTB-National Project for FSE frame)
  - + Application example (existing hotel)
- **End of the 80's : development of a stochastic approach of fire safety in public building**
  - Event modeling with Petri nets

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**Case Study**


→ **Problem to solve :**

- + A real hotel under restoration needs to comply with up to date prescriptive rules
- + Smoke control inside room corridors is mandatory
- + No technical possibilities to install a smoke control system in this existing building

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- Can we forget about smoke control ?
- What kind of safety measures shall we use in compensation in order to maintain the fire safety level of this hotel ?

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**Performance-based approach**


→ **What we want to do:**

- Estimate a fire safety level
- Estimate the effect of fire safety measures of different nature (active, passive, behavior and actions of individuals, etc.) on this level
- Take into account time (delay of practicability ? delay of people evacuation ?)
- Take into account physical phenomena (spread of smoke and fire inside the building)
- Quantify using computer simulation

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**Development of a new modeling tool: SCHEMA-S.I.**

→ **Full coupling between :**

- Continuous Fire phenomena using a multi-room 2-zone model  
[like CIFI (CSTB), C-FAST (NIST) or BRI2002 (BRI)]
- Discrete events using a Petri net formalism  
[OO-DPT: **O**bject **O**riented **D**ifferential **P**redicate **T**ransition Petri nets - see E. Villani, Journal of Nonlinear Analysis, 2005-2006]
- Stochastic aspects using Monte-Carlo simulation

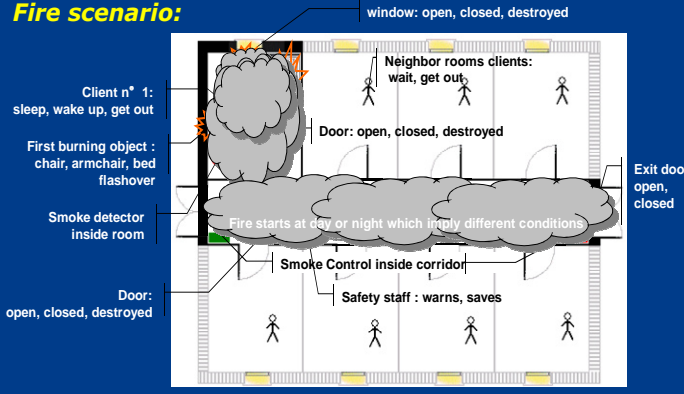
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**Application to an hotel room fire**

→ **Fire scenario:**



Labels in diagram:  
 - window: open, closed, destroyed  
 - Client n° 1: sleep, wake up, get out  
 - Neighbor rooms clients: wait, get out  
 - Door: open, closed, destroyed  
 - Exit door: open, closed  
 - Fire starts at day or night which imply different conditions  
 - Smoke detector inside room  
 - Smoke Control inside corridor  
 - Safety staff : warns, saves  
 - Door: open, closed, destroyed

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There is a lot of parameters...

→ **Scenario data (1/5)**

- **Fire extension**
  - First burning object
  - Growing speed
  - Flashover
- **Passive and active safety measures**
  - Door, window, closing-door system
  - Smoke detector
  - Local Sound alarm
  - Smoke Control system
- **Human behavior**
  - Clients
  - Safety staff
  - Fire Brigade

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...just like any other fire model...

→ **Scenario data (2/5)**

- Fire extension

Parameter	value	unity	Comment
1 <sup>st</sup> Burning Object	Uniform [1, 2 or 3]		1 : chair ; 2 : armchair ; 3 : Bed
Growing speed	Uniform [60, tpl/2]	s	tpl : instant where the object HRR is max
Flashover	Uniform [500, 600]	°C	

Temporal evolutions of the mass release rate during the growing phase of the fire activity for the 3 objects

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Example of results on the room fire scenario

→ **Some fire safety measures**

1. Detection in the corridor
2. Detection in the room
3. Smoke control in the corridor
4. Closing-door system
5. Safety staff actions
6. Local sound alarm in the room

→ **Some fire safety strategies (schemes)**

- A. 1, 5 (before renovation)
- B. 1, 2, 4, 5 (wanted by the building owner)
- C. 1, 3, 4, 5 (mandatory)
- D. 1, 2, 4, 5, 6

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Example of results on the room fire scenario

→ **Fire safety level for each strategy: frequency of Not Wanted Events**

- Several death
- Client n°1 death (room where fire starts)
- Hotel Safety Staff death
- Room flashover

→ **Other events useful for analysis:**

- Safety staff is aware of the fire
- Safety staff rescue the neighbor rooms clients
- Fire brigade rescue the neighbor rooms clients
- ...

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Example of results on the room fire scenario

Not Wanted Event	Frequency (%)			
	A	B	C	D
Several death	3,4	1,2	1,9	1,1
Client n° 1 death	51,0	39,8	50,5	31,6
Safety staff death	0,8	1,4	1,4	1,3
Flashover in the room	8,4	3,2	3,0	2,9

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Conclusion

→ **SCHEMA-S.I. provides to the safety actors a framework to:**

- **Understand each other and choose the fire safety measures to be evaluated** (what do we want to do and what can we do ?)
- **Make a full functional analysis of the safety measures** (what is the point and how does it work?)
- **Use state of the art knowledge to quantify** (what do we know and which value shall we retain ?)
- **Highlight the interactions between the different safety measures**
- **Quantify a fire safety level, compare fire safety strategy and take decisions**

→ **We think these tool and approach are an interesting way for Fire Safety Engineering...**

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