BDI multi-agent modelling of the population's decision making in a bushfire

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Black Saturday

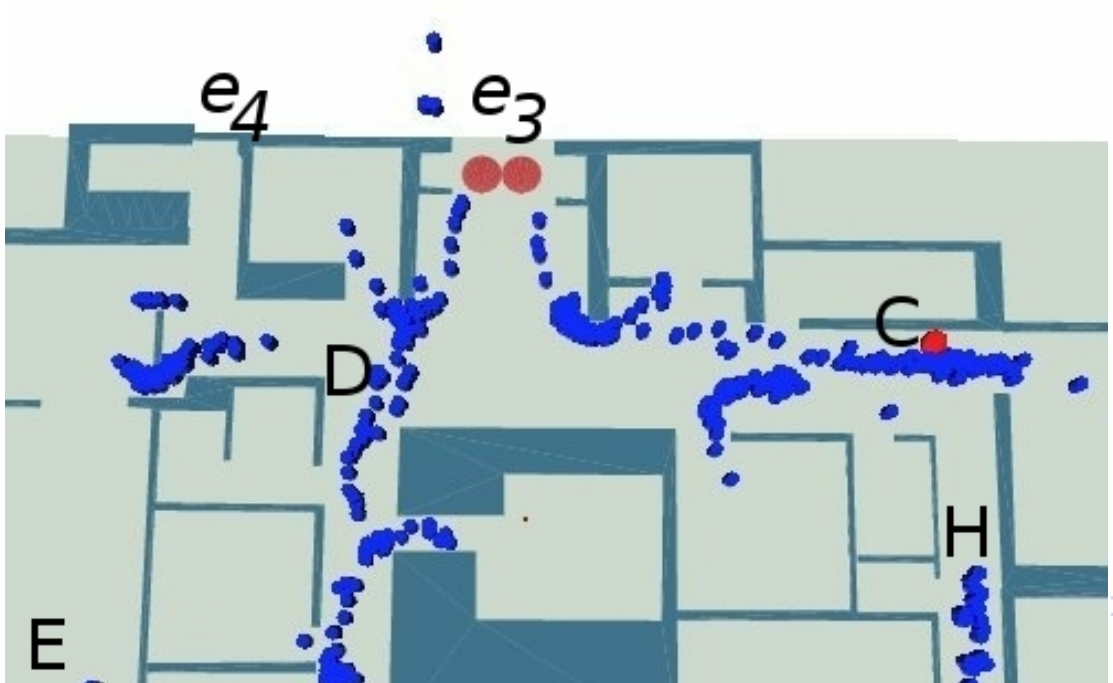
- 7 February 2009,
- 173 dead et 414 injured,
- $\sim$ 450 000 ha burned.
- The expected behaviour is different from the reality,

SWIFT project:
$\rightarrow$ Make a serious game in order to raise the awareness of the emergency managers about the real population behaviour.
$\rightarrow$ Simulation must be as realistic as possible.

Computer simulation

Why computer simulation ?

- Repeatable,
- Controllable,
- Cheap,
- Safe.



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State Of the Art

The existing simulations are focused on:

- Fire behaviour [Duff et al., 2013],
- The crowd behaviour during building and public area evacuation
  [Kuligowski, 2008, Pan et al., 2006, Pelechano et al., 2005],
  - Basic and homogeneous behaviour,
  - Lack of human factors (emotions, determination, ...),
  - Ignores pre-evacuation.

$\rightarrow$ Simulation based on a cognitive architecture.

State Of the Art (2)

Simulations using a cognitive architecture exist but:

- Evacuation in public area
  → behaviours are different in a personal house [Tsai et al., 2011],
- Focus on performance and scalability
  → homogeneous behaviour without personality [Cho et al., 2008].

→ Use a top-down approach
(from the theory to the implementation).

Proposal

- Make a **realistic** simulation of Autralian population behaviour in bushfires.

→ Require valid results,

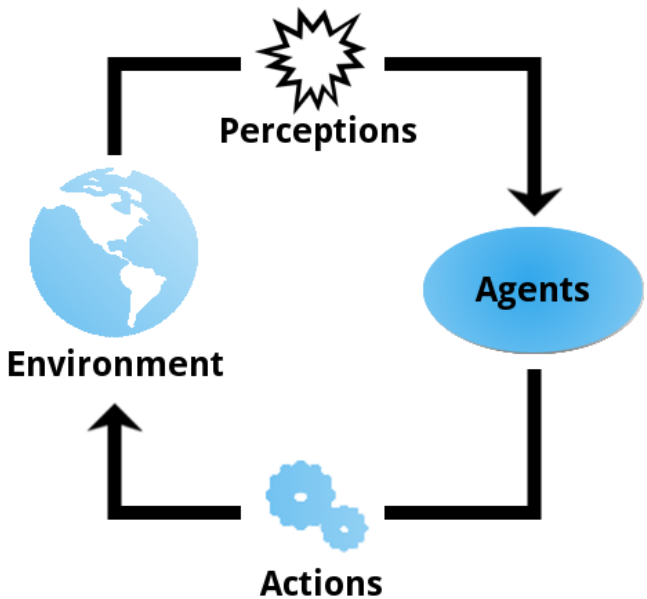
→ Use of cognitive architecture.

Simulation Multi-Agent

What is an agent?

Autonomous system which perceives and interacts with its environment.

- Multiple agents coexist and interact.
- Different agent architectures of varying complexity.



Belief Desire Intention

Beliefs

Information about the environment, itself or the other agents. It can be **incomplete** or **incorrect**.

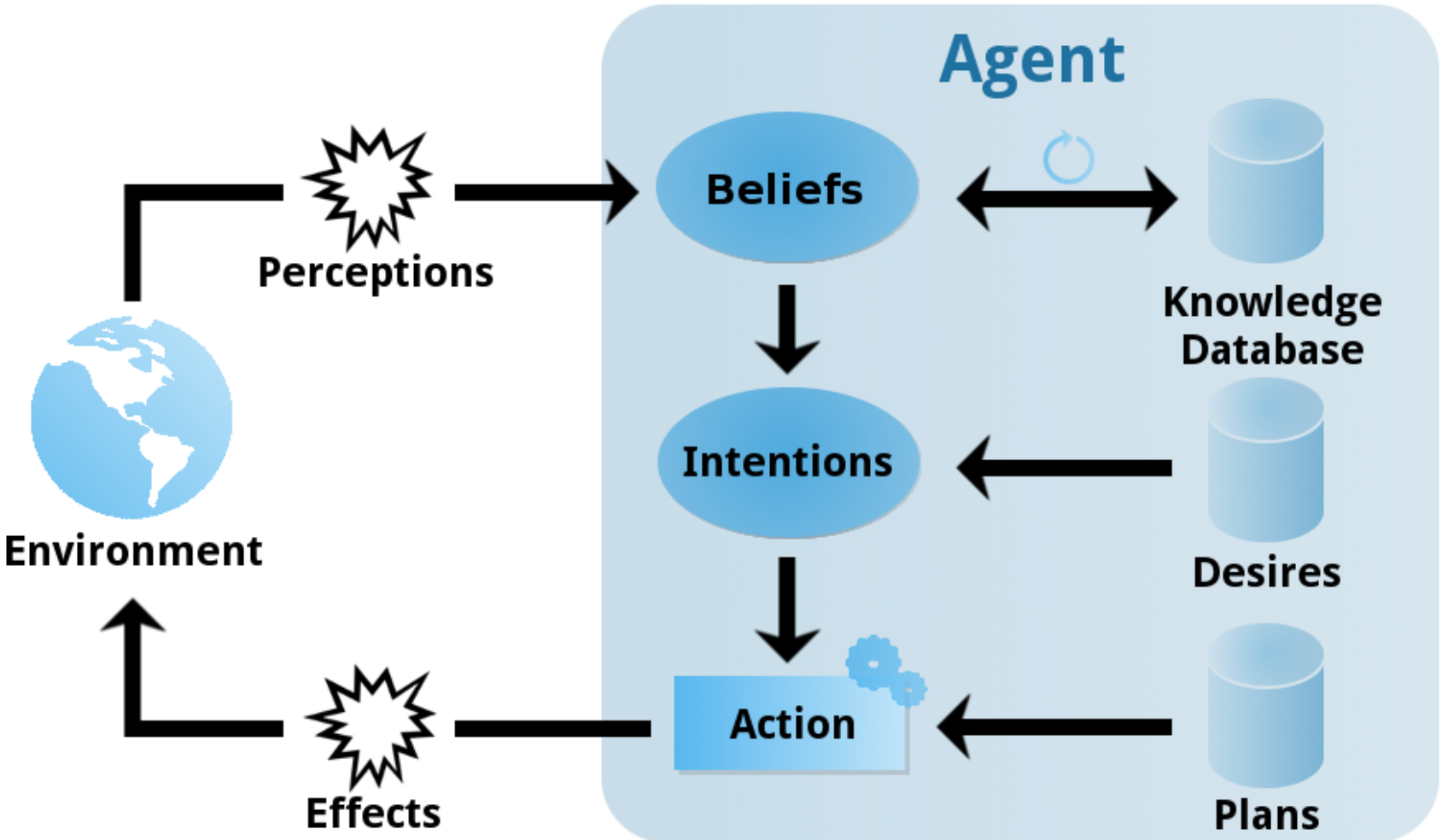
Desires

Motivations to do something. It can be **inconsistent** or **unrealistic**.

Intentions

Leads to **action**.
Selected from the **desires** and **beliefs** of the agent. It can have several associated **plans** allowing to achieve it.

Believe Desire Intention (2)



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Witness Statement [VBRC, 2009b]

Sue Exell

*"I **looked** out the window and **saw** some hazy smoke to the north-west ..."*

→ Perception

Witness Statement [VBRC, 2009b]

Sue Exell

*"... Gary said that he **thought** it was just dust but we went outside ..."*

→ Belief

Witness Statement [VBRC, 2009b]

Sue Exell

*"... and straight away we **noticed** that we could **smell** smoke ..."*

→ Perception

→ New belief (updated)

Witness Statement [VBRC, 2009b]

Sue Exell

"... as soon as that happened, Gary agreed to ***go and get the fire pump.*** *..."*

→ Intention : defend their property,

→ First plan : Prepare the fire pump.

Tactics Decision Framework (TDF)

TDF is a tactical decision-making modelling tool based on the Prometheus methodology [Evertsz et al., 2015]. It provides:

- BDI Based paradigm,
- Structural modelling of missions, goals, scenarios, input/output, messaging and procedures.

Tactics Decision Framework (TDF) (2)

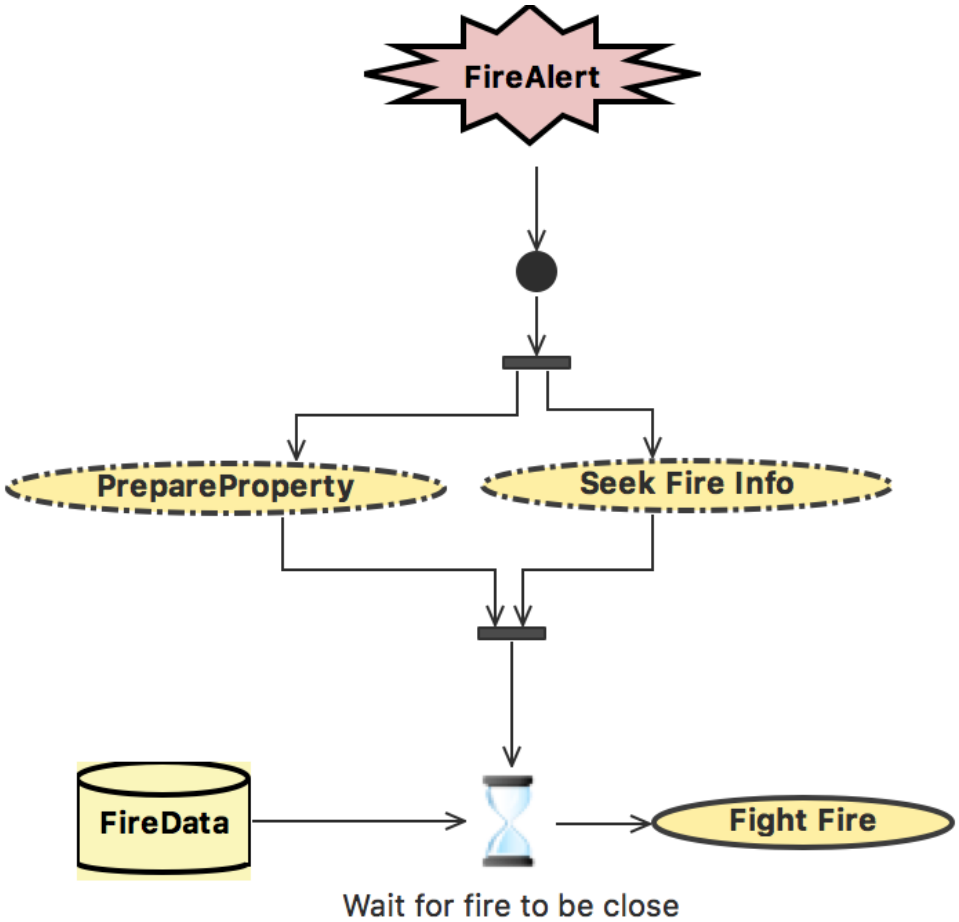

Figure: Plan diagram example

GAMA and GAML

- Open source development platform
- GAML language
- BDI extension

Perception exemple

```
perceive target:fire in:perception_radius {
  add self to: myself.known_fires;
  ask myself {
    do add_belief (fire);
  }
}
```

Civilian's Profiles

A previous study by Alan Rhodes shows there are 6 existing profiles [Rhodes, 2014]:

- Can do defender: "Just do it, just get on with it"
- Considered defender: "You have to be prepared if you choose to live here"
- Livelihood defender: "It's not just a house, it's our livelihood"
- Threat monitor: "I'll leave when I need to - before it's really dangerous"
- Threat avoider: "Life is more important than the house"
- Unaware reactor: "I didn't expect a fire like that - I was shocked"

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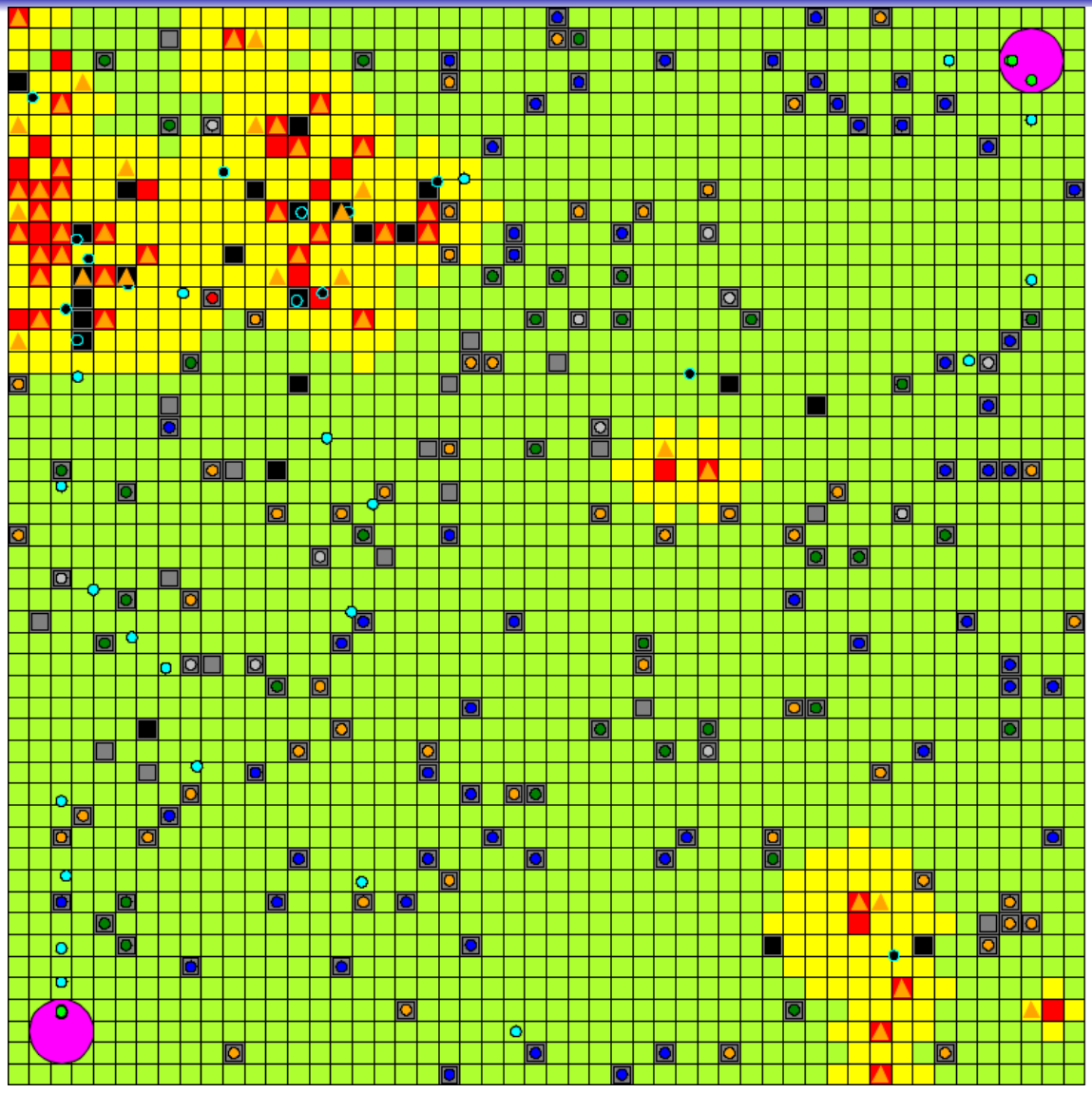
Implementation

BDI architecture based on a Finite State Machine (FSM) made in a previous study [Adam et al., 2015] and on the witness statements data [VBRC, 2009c].

- Grid which represents the map,
- 200 "Pedestrian" BDI agents (Australian citizens),
- 200 houses (one per Pedestrian agent),
- 2 shelters,
- Basic fire implementation (random propagation).

Graphical rendering



Demo

vids-background.png

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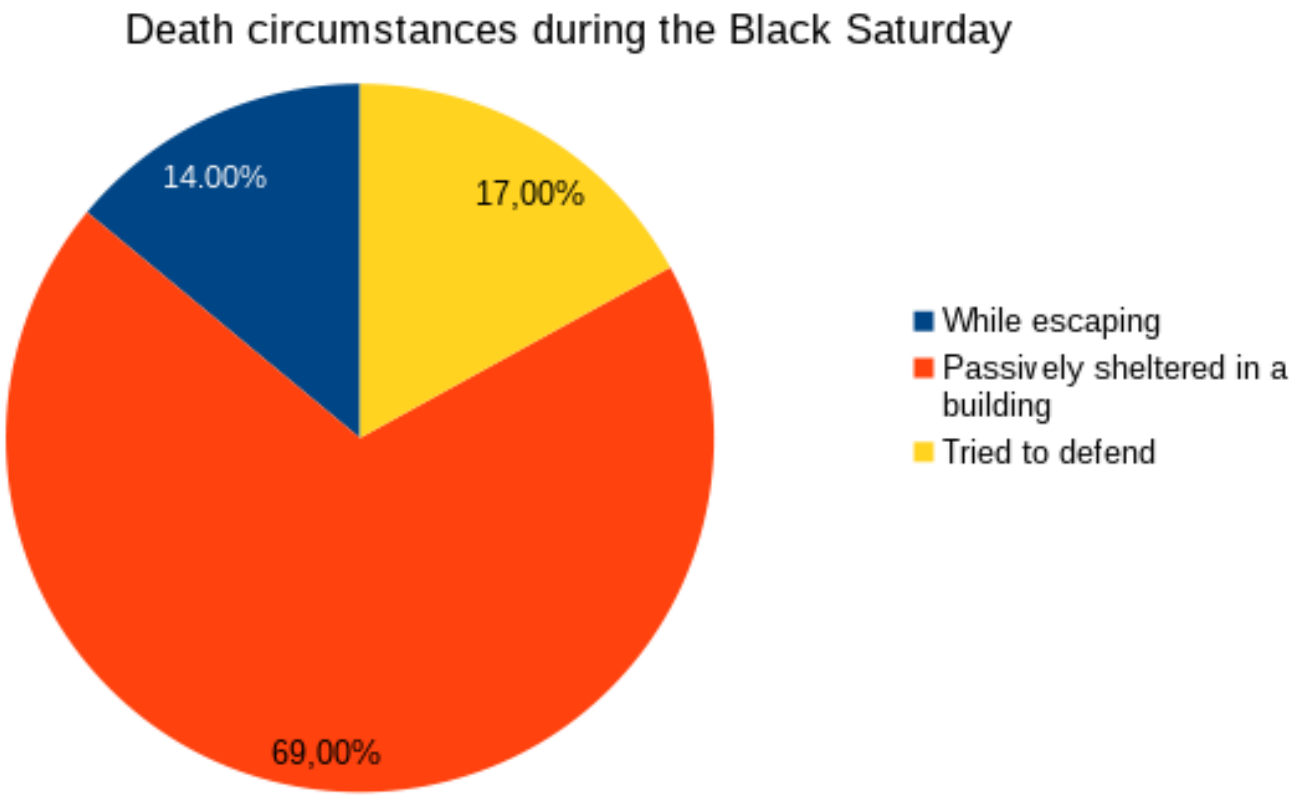
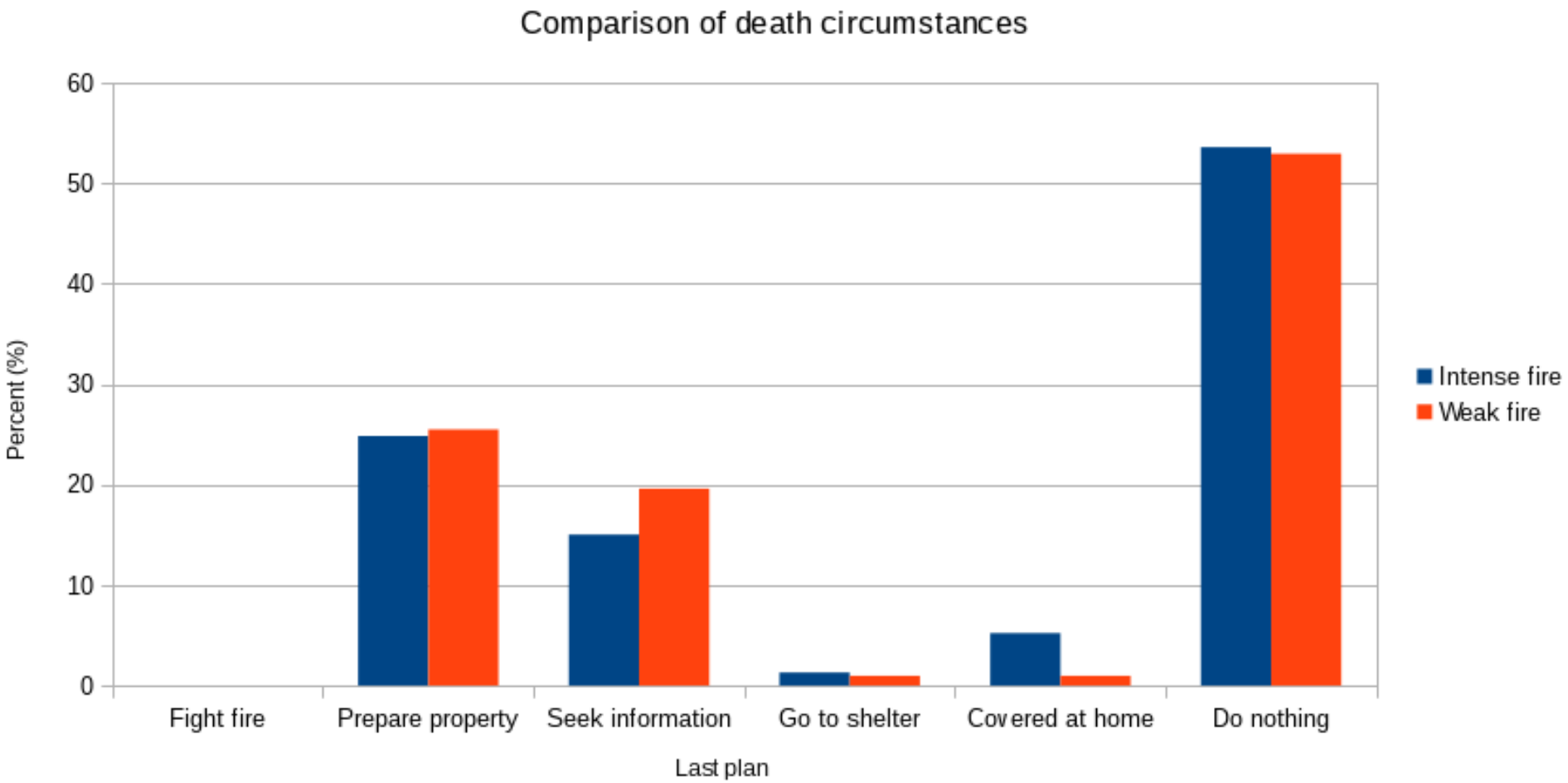
Experiments

- 2 different parameters sets,
  - Weak fire: low intensity and low propagation rate,
  - Intense fire: high intensity and high propagation rate.
- Each experiment includes 500 cycles and 10 simulation iterations,
- The results will be compared between them and with the statistics from the Victorian Bushfires Royal Commission [VBRC, 2009a],

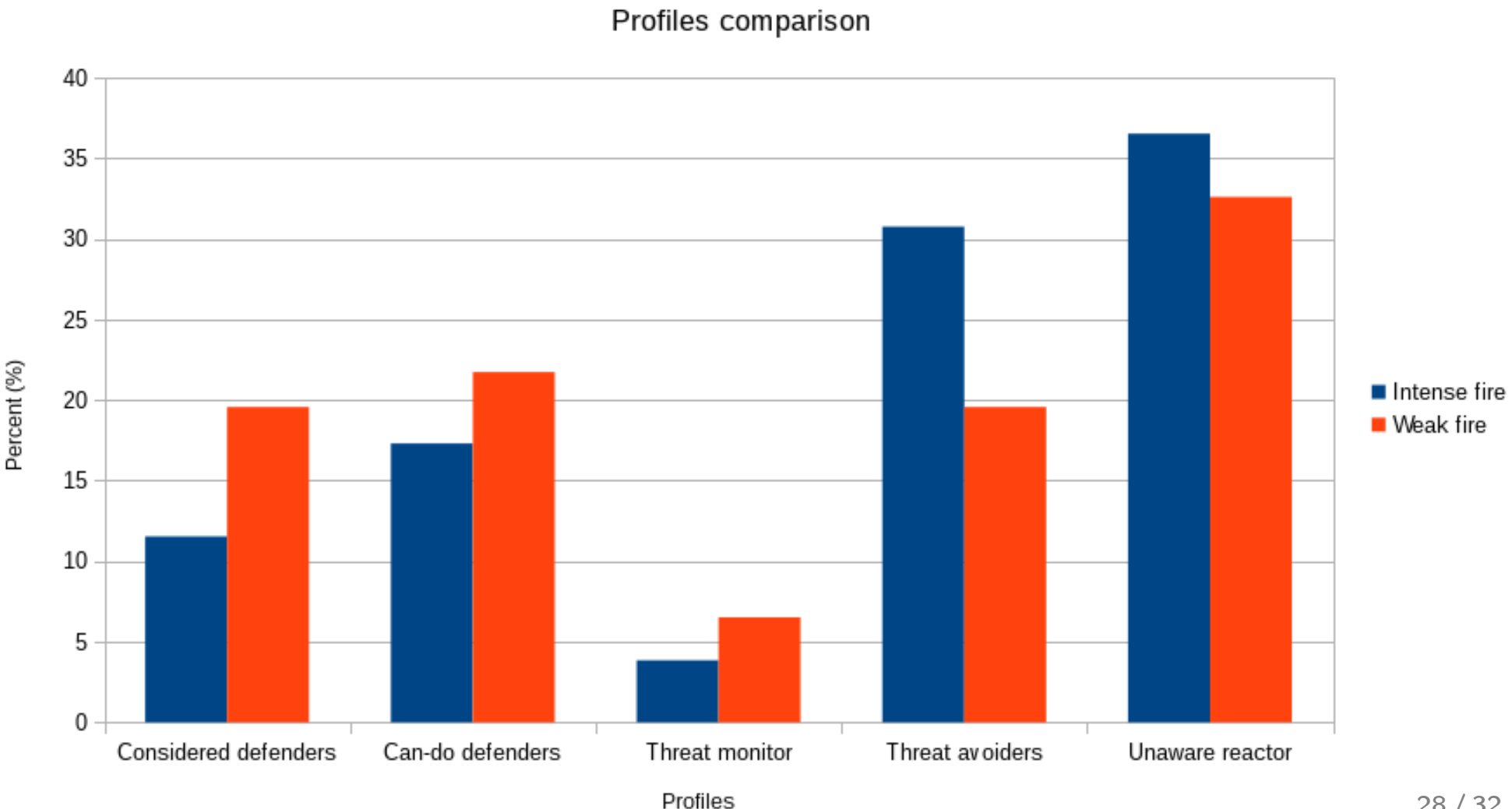
Statistics


Death circumstances during the Black Saturday
14.00%
17,00%
69,00%
While escaping
Passively sheltered in a building
Tried to defend

Result: death circumstances



Result: profiles



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Contribution

- Followed a bottom-up methodology:
  Interviews $\rightarrow$ TDF $\rightarrow$ GAMA,
- implemented a realistic BDI model,
- Studied model validity,
- Provided feedback on GAMA and TDF,
- Submitted paper to ISCRAM-med 2016 (under review).

Future Work

- Compare BDI vs Finite State Machine (FSM),
- Improve the BDI implementation
  (add emotions, social relationships...),
- Integrate a more realistic fire model
  (SPARK [Miller et al., 2015]),
- Take into account the topology (road, forest...)
- Subject of a PhD Thesis.

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Questions are welcome.

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