PROGRAM A

COUPLING BUSHFIRE SPREAD WITH A SENSOR NETWORK DETECTION SYSTEM MODEL

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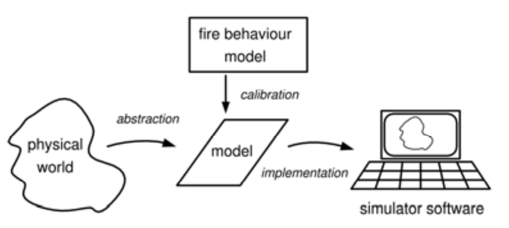
Outline

1. Bushfire simulation
2. Efficiency of the discrete event approach
3. The Mt Cooke fire and simulations
4. Simulation of Bushfire Sensor Networks

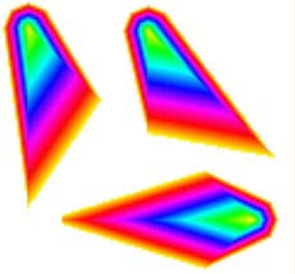
Bushfire simulation - components



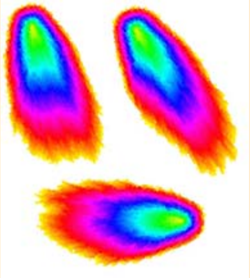
Cell based simulation

- In a cell based approach, the landscape is divided into small pieces, usually of equal area that represent the fuel, topography and fire state (unburnt, burning or burnt) through time.
- Cell approaches have traditionally had difficulty producing realistic fire shapes.
- Regular grids introduce bias aligned with the grid orientation which is the same everywhere.
- Irregular grids also introduce bias but the bias is different at each location and over a moderate sized region, cancel out.
- A more sophisticated computational model is required to implement irregular grids.

Regular grid

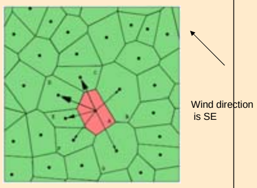


Irregular grid



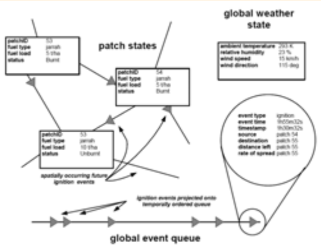
Fire spread by propagation delay

1. Each cell/patch has approximately 6 neighbours
2. When a patch is ignited, the patch's fuel type, moisture, wind speed and direction and the appropriate fire behaviour model are used to calculate the head fire rate of spread
3. The distance and direction to each neighbour determine the time it takes to ignite each neighbour from the current patch.

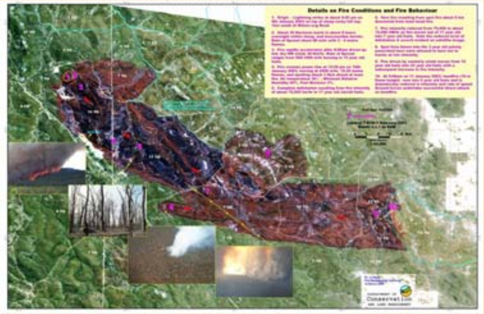


Efficiency

1. The BushfireCRC fire simulator is a *Discrete Event Simulator*
2. Instead of propagating the entire fire front at given time steps, the ignition of each patch occurs in a time-ordered sequence.



Mt Cook Fire, WA, 9-11 January 2003 (courtesy of Department of Environment and Conservation, WA)

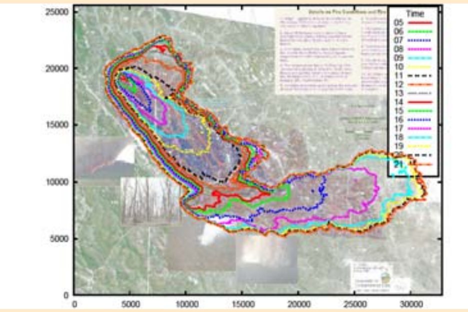


Simulation of Mt Cooke fire: Input data

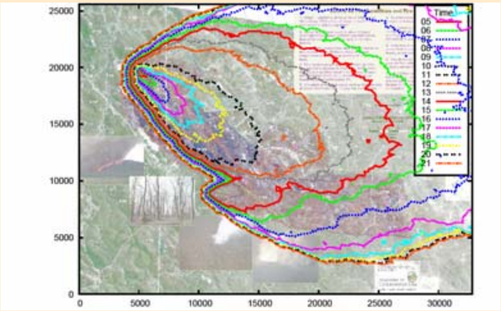
- Northern Jarrah fuel type with fuel loads calculated from time since previous fire (Red book)
- Surface Moisture Content versus time (calculations by L. McCaw, DEC)
- Wind speed versus time from weather station away from fire ground multiplied by a single scale factor
- Wind direction inferred from fire shape.
- Ignition at 4 am 10 Jan, plus spot fire at 12 noon
- Topography

Simulation with observed wind speed x 1.25

Simulation with observed wind speed x 1.3



Simulation with observed wind speed x 1.3, and all fuel 15 years old



Lessons learnt from simulation of Mt Cooke fire

- Each simulation took around 1 second to run for patches of approx. 250 m diameter
- A small increase in wind speed causes a large increase in area burnt
- Reduced fuel load due to prescribed burns contained the fire on the northern flank
- The BushfireCRC simulator reproduces fire spread with slight modification of input data
- Red book possibly under-predicted ROS for this fire?

Fire simulator conclusions

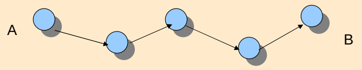
1. Simulator is very fast
2. Irregular grid provides more realistic fire shapes
3. Initial validation is promising
4. Rapid simulation allows us to consider applications involving multiple simulations allowing for the uncertainty in the input data (forecast weather, fuel moisture model, fire behaviour model, probabilistic spotting model)
5. Further development required on user interface, data import, inclusion of spot fire model

Outline

1. Wireless Sensors
   a) what are they?
   b) how can we use them?
2. Modelling – why do it?
3. Simulation
   a) Overall Stucture
   b) Cell Structure
   c) Layers
   d) The Process
   e) How does the Fire Simulator fit in?
4. Progress – What remains to be done?

Wireless Sensors

1. Low-power, low-cost, autonomous;
2. Gathers data on temperature, moisture and more;
3. Have short-range radios;
4. Share their data with other sensors using radio;
5. Help each other deliver data to other sensors



Possible Applications

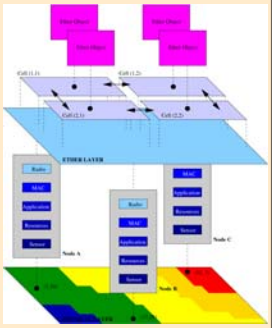
1. Early Detection
   a) Potential for very early detection;
   b) Fine-grain location of fires;
   c) Autonomous;
2. Fire Data Gathering
   a) Intensity;
   b) Rates of spread;
3. Weather Data
   a) Weather data at high resolutions to improve fire behaviour model;
   b) Fine-grain micro-climate data to feed into fire predictors;

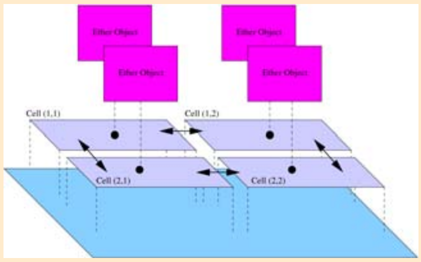
Modelling

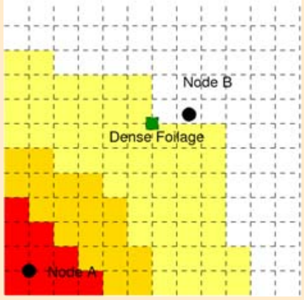
1. Wireless Sensor technology is (still) new and unreliable.
2. Need experimentation to determine feasibility and optimal configuration of sensors.
3. Real-world experimentation difficult, dangerous or impossible.
4. Develop model/simulator that can be extended as sensor technology evolves.

Overall Structure

1. Each aspect of the system is captured in a separate module.
2. Modules can contain other modules.
3. Modules interact by exchanging messages, which produces simulation







Cell structure – Radio Signals

1. Use cell approach to model radio signals.
2. Each cell contains the translation of a Finite State Machine.
3. Finite State Machines explicitly model the behaviour of a small portion of the radio medium.
4. Each cell communicates state changes to their neighbours
5. This interaction produces the behaviour of wireless radio signals

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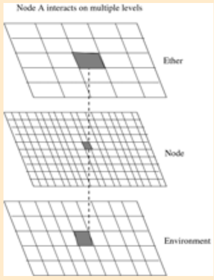
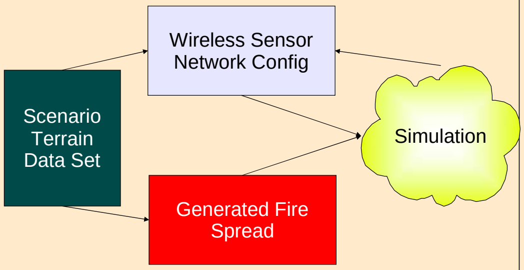
Layers of Data

1. Dynamic spatial data
   a) Radio Signals, Fire, Heat, Moisture and more!
2. Each piece of data is represented as a separate layer of cells.
3. We do this because the cell size and cell connectivity requirements for each data type is different.
4. Translation interfaces at each layer.



Simulation Process

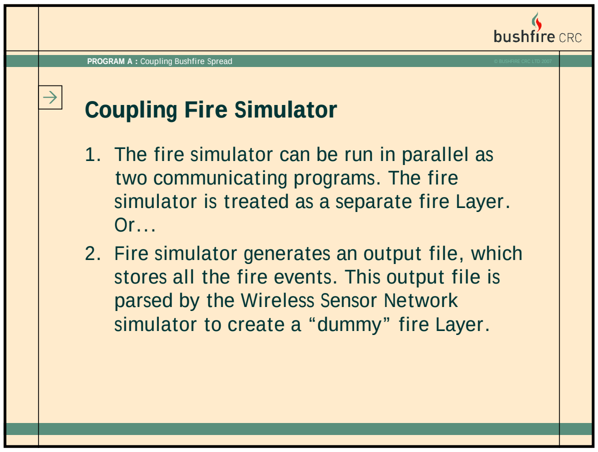


Wireless Sensor Network Config

Scenario Terrain Data Set

Simulation

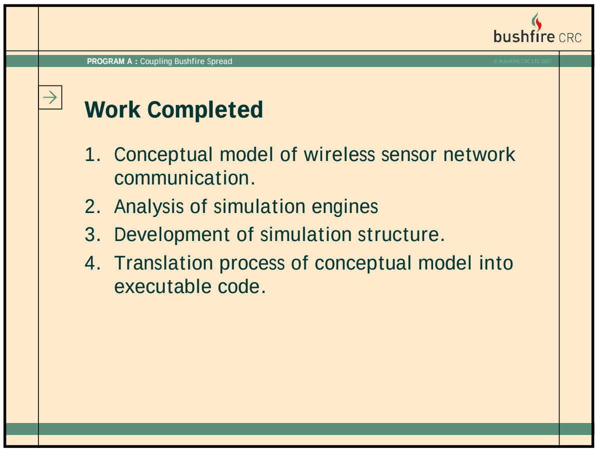
Generated Fire Spread



bushfire CRC

Coupling Fire Simulator

1. The fire simulator can be run in parallel as two communicating programs. The fire simulator is treated as a separate fire Layer. Or…
2. Fire simulator generates an output file, which stores all the fire events. This output file is parsed by the Wireless Sensor Network simulator to create a “dummy” fire Layer.



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Work Completed

1. Conceptual model of wireless sensor network communication.
2. Analysis of simulation engines
3. Development of simulation structure.
4. Translation process of conceptual model into executable code.