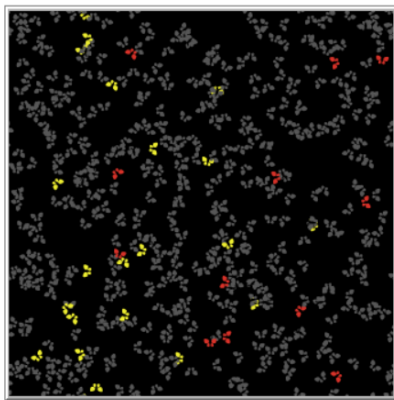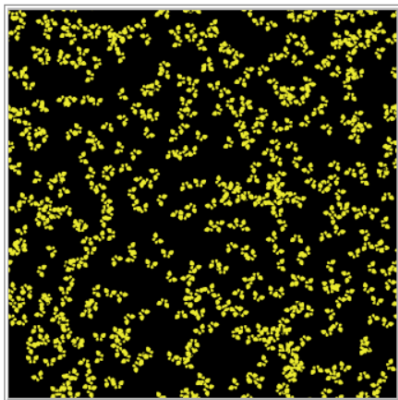# Firefly synchronization in multiple scenarios

Mezzina Marco

Objective

► Study the convergence time of fireflies which synchronize their
flashing using only the interactions between the individual ones
in specific scenarios.

Parameters

Starting from the NetLogo basic model

- ▶ Fixed parameters

| Strategy	flash-length	flashes-to-reset	cycle-length
Delay	1	1	10

- ▶ Tested parameters (combined)
  - ▶ Fireflies number at equals density: 100, 250, 500 and 1000
  - ▶ Fireflies motion: ON and OFF
  - ▶ Fireflies byzantine percentage: 1%, 5%, 10%, 15% and 30%
  - ▶ Fireflies byzantine fault probability: 1%, 2% and 30%

Metrics

The used metrics to test the previous parameters have been

- ▶ Flashing fireflies
- ▶ Fireflies flashes per ticks
- ▶ Window emission length
- ▶ Consecutive flashes
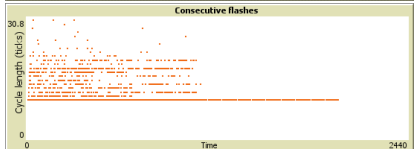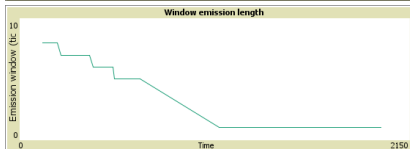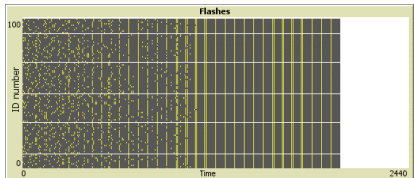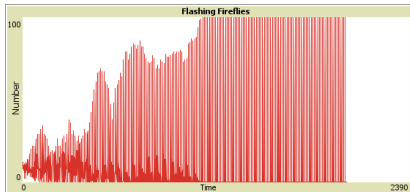
Behaviour classes

- Convergence
- Divergency
    - periodic
    - chaos
    - perturbation of the periodic behaviour

Convergence

This situation surely appears in the system when the motion is granted and, independently by the fireflies number, no byzantine fault occurs.
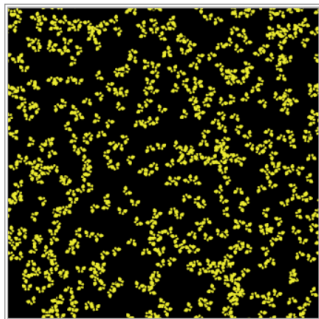

Figure 1: Convergence
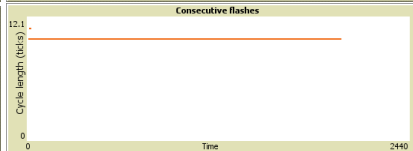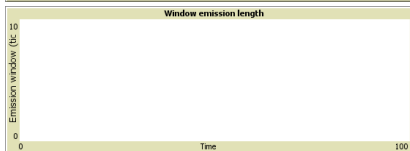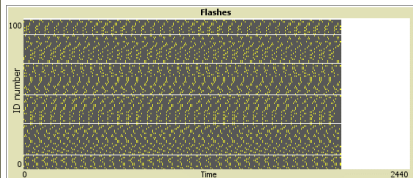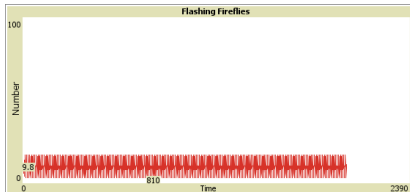
Divergency (Motion parameter)

Indipendently by the fireflies number with motion parameter fixed to OFF happens that:

- ▶ periodic behaviour appears: some fireflies regions are synchronized separately
- ▶ connectors fireflies
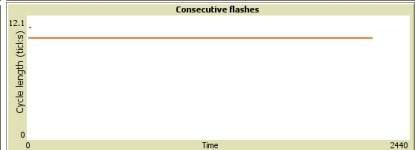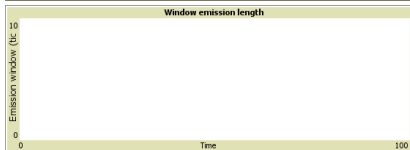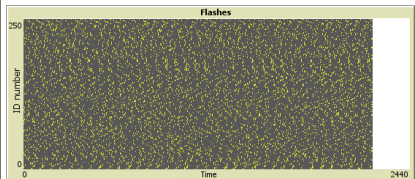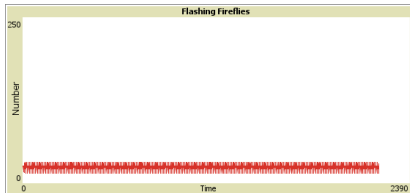- ▶ empty window emission length

Some experiments. . .

Divergency (Motion parameter)

FN	M	BP	BFP
100	OFF	0%	0%

Divergency (Motion parameter)

FN	M	BP	BFP
250	OFF	0%	0%

Divergency (Motion parameter)

FN	M	BP	BFP
500	OFF	0%	0%
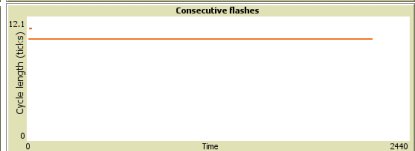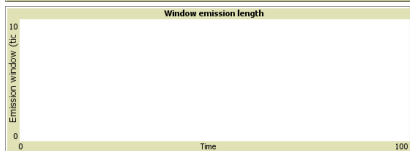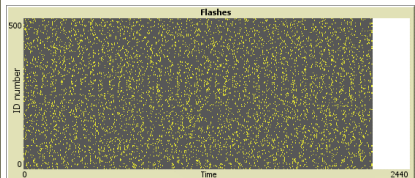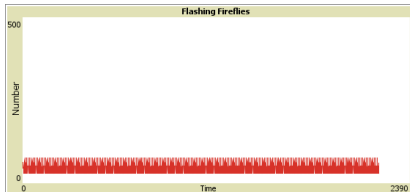
Divergency (Motion parameter)

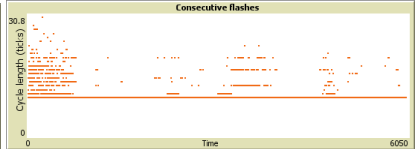| FN	M	BP	BFP
1000	OFF	0%	0%
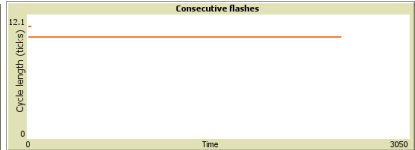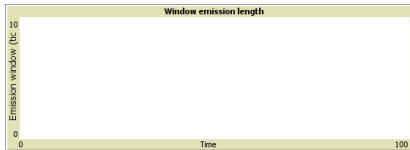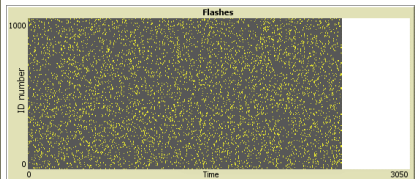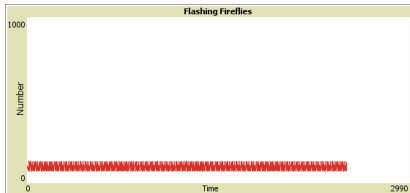
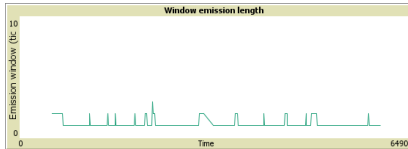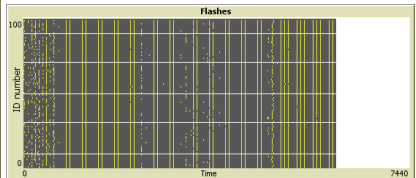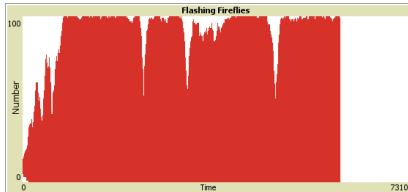# Divergency (BP and BFP)

The experiments show that the network is really sensitive to byzantine faults.

- ▶ BP and BFP fixed to 1%
    - ▶ temporary convergence
- ▶ BP and BFP greater or equals to 2%
    - ▶ rare temporary convergence
    - ▶ no window emission length with a lot of fireflies
- ▶ Increasing the nodes number the window emission length grows up as also the ticks to reach the temporary convergence.
- ▶ The euristic treshold values are BP=15% and BFP=2%, after them the chaos is unmanageble also for low number nodes networks.

Some experiments. . .
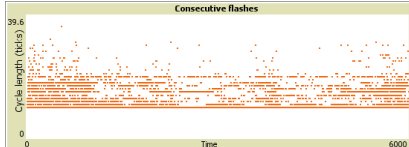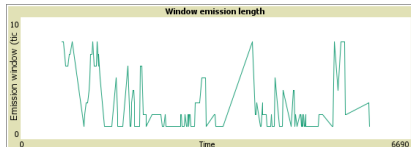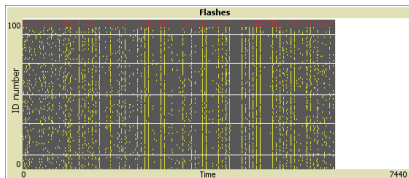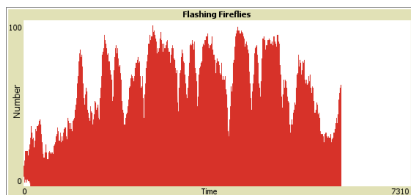
Divergency (BP and BFP)

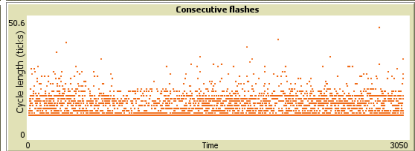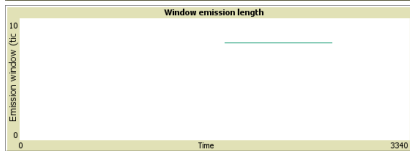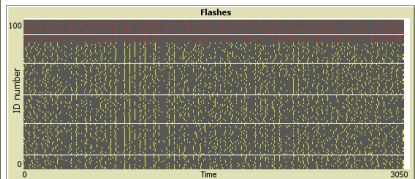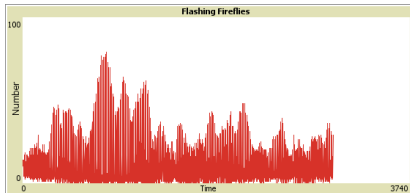| FN	M	BP	BFP
100	ON	1%	1%

Divergency (BP and BFP)

Very similar behaviour for the case with 250 fireflies.

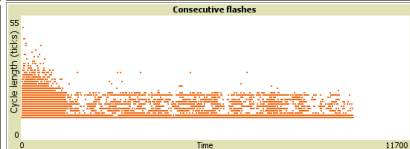| FN	M	BP	BFP
100	ON	5%	2%

Divergency (BP and BFP)

FN	M	BP	BFP
100	ON	15%	2%

Divergency (BP and BFP)

FN	M	BP	BFP
1000	ON	1%	1%

Divergency (BP and BFP)

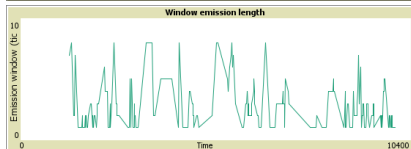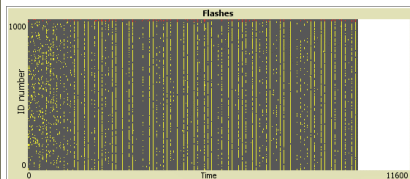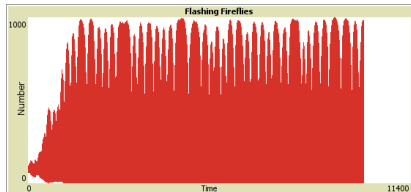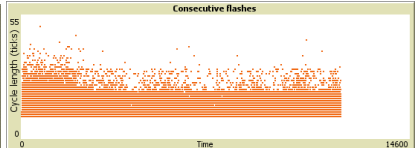Very similar behaviour for the case with 500 fireflies.

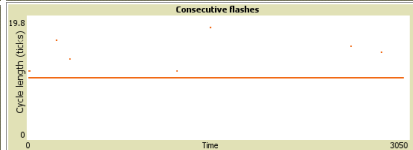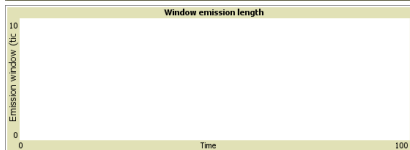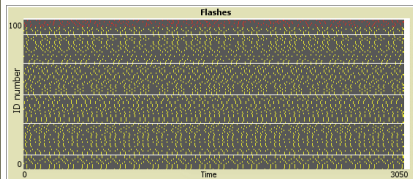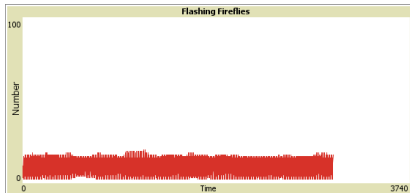| FN	M	BP	BFP
1000	ON	5%	2%
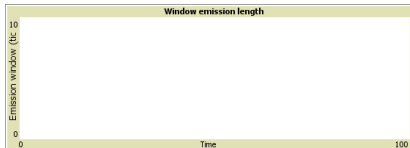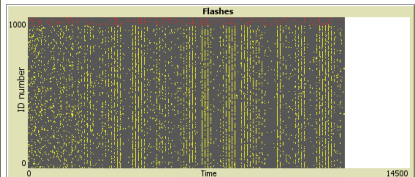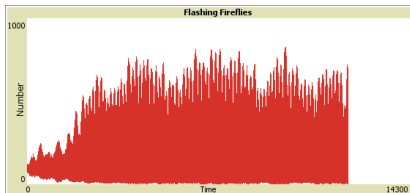
Divergency (Motion + BP and BFP)

- The system staticity is conditioned by the byzantine perturbations
- It's obtained a perturbation of the periodic behaviour

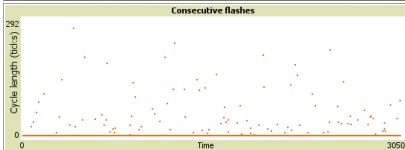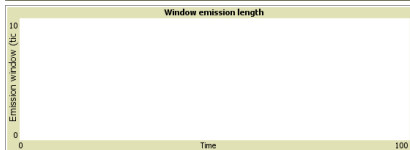Some experiments. . .

Divergency (Motion + BP and BFP)

FN	M	BP	BFP
100	OFF	5%	1%

Divergency (Motion + BP and BFP)

It's interesting to observ that if we significantly increase the BP and BFP values without motion we obtain a system behaviour more or less similar to the previous cases.

FN	M	BP	BFP
100	OFF	30%	30%
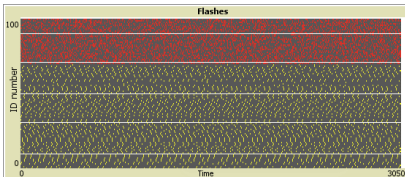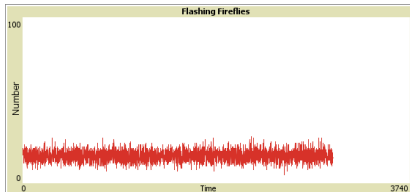
Divergency (Motion + BP and BFP)

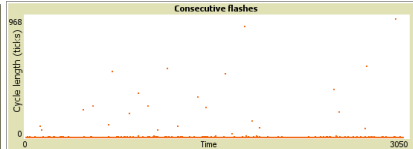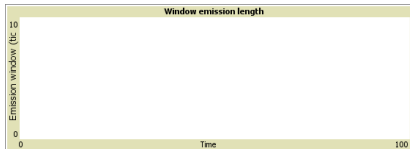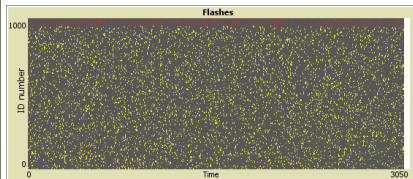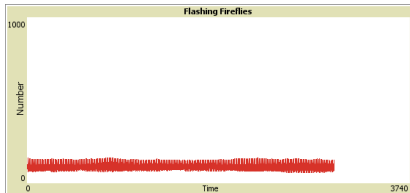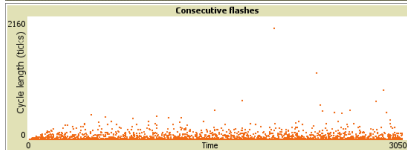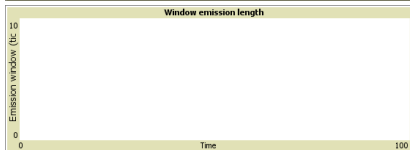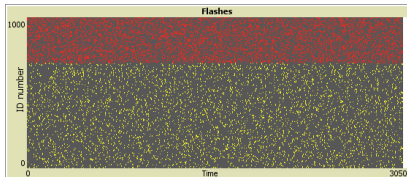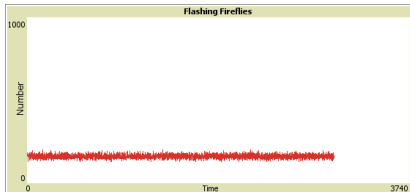| FN	M	BP	BFP
1000	OFF	5%	1%

Divergency (Motion + BP and BFP)

It's interesting to observ that if we significantly increase the BP and BFP values without motion we obtain a system behaviour more or less similar to the previous cases.

FN	M	BP	BFP
1000	OFF	30%	30%

Final Considerations

At the end, we can say:

▶ The fireflies motion is the most important parameter to obtain light stimuli distributed perception. Without motion only periodic behaviour appears.

▶ Byzantine faults cause frequency and shapes alterations of periodic structures, also with very poor values variation it's difficult to reach a consistent convergence.

▶ The fireflies number variation involves different convergence time, but doesn't really affect the convergence of the system.

Thanks for the attention