A Comparative Cross-Domain Study of the Occurrence of Laughter in Meeting and Seminar Corpora

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May 28, 2008

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- primary motivation: conversation understanding

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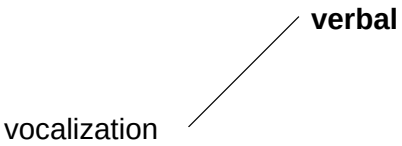

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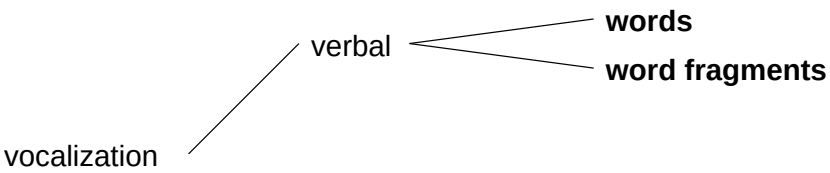

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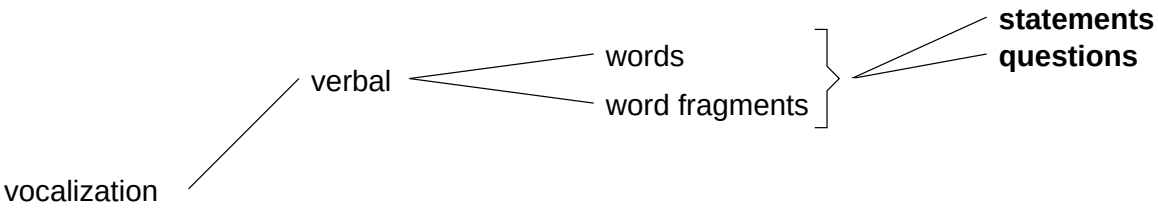

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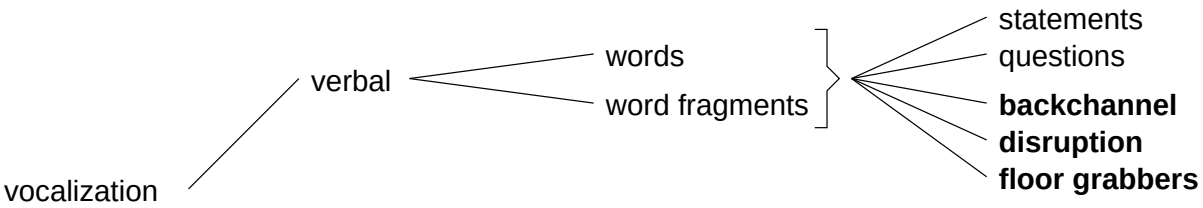

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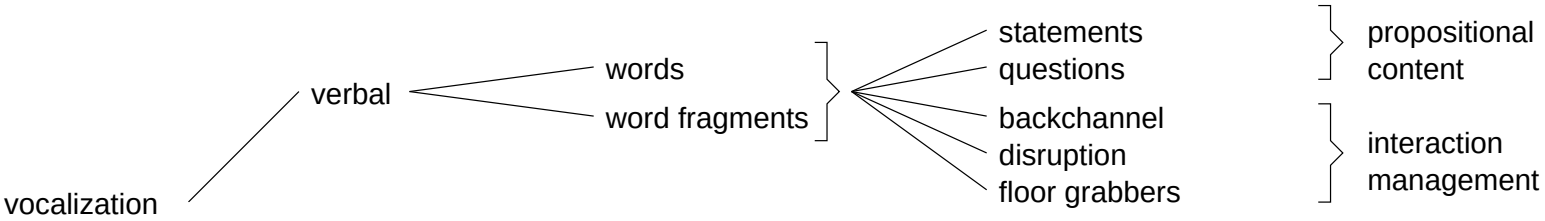

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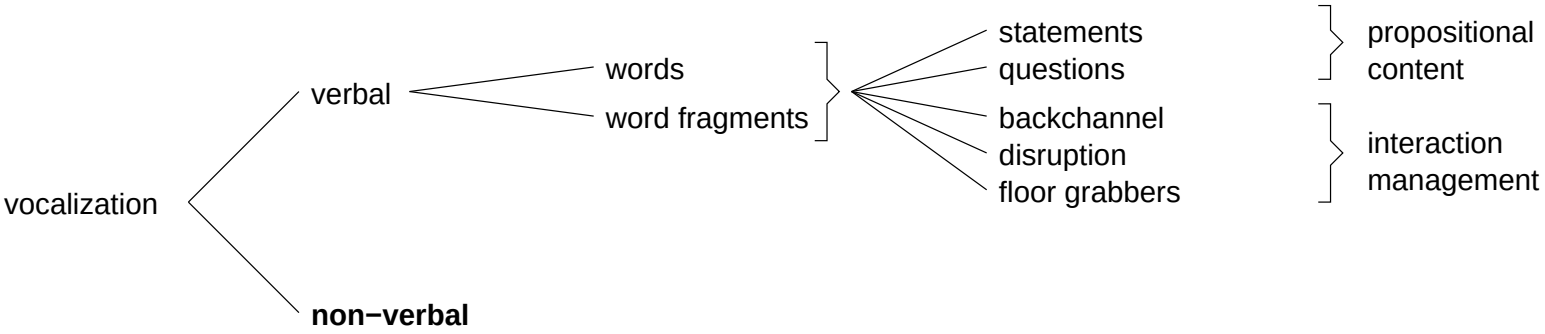

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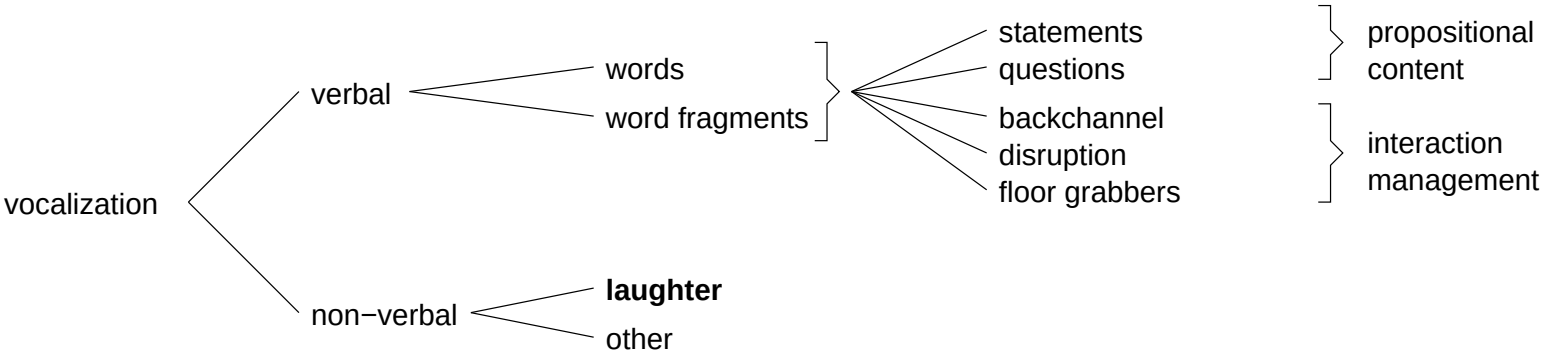

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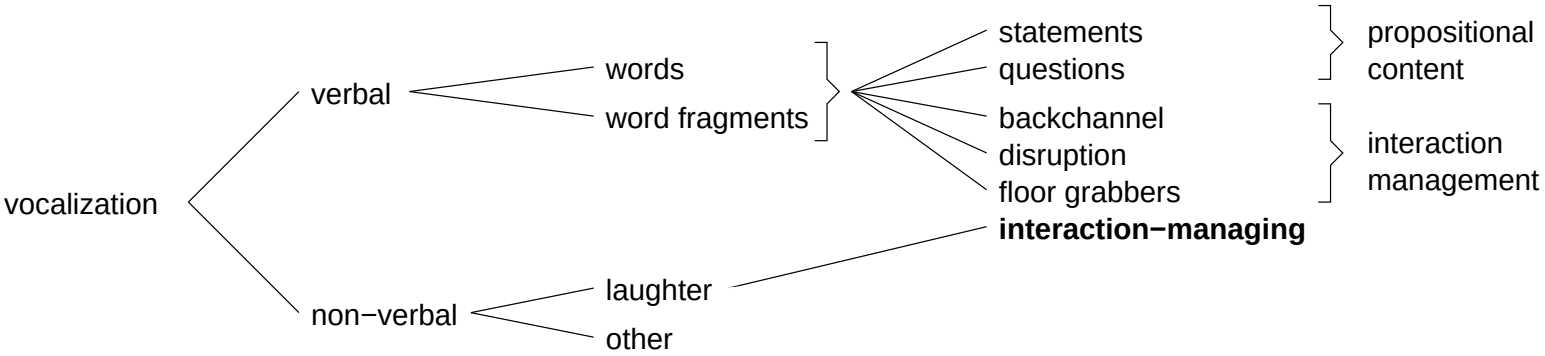

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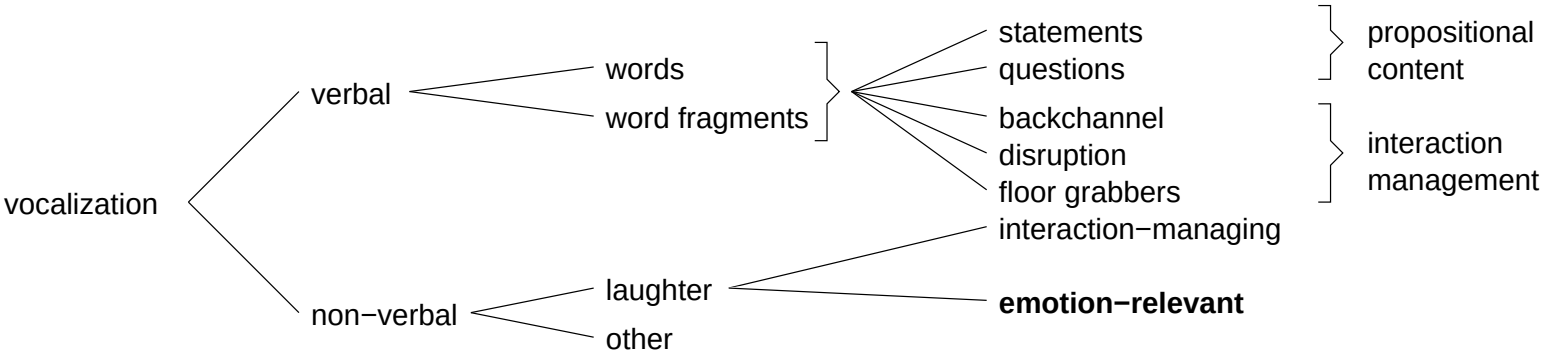

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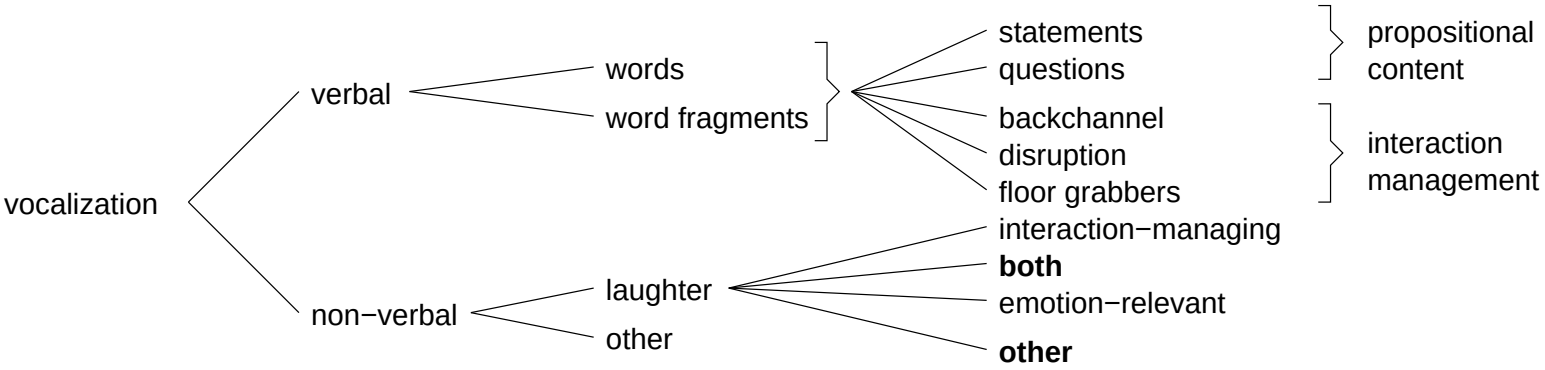

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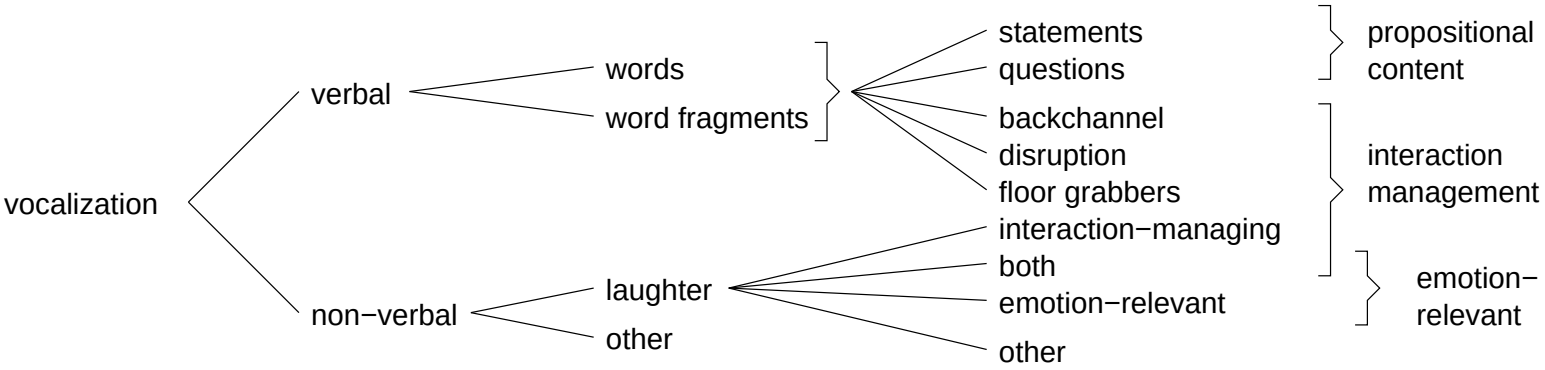

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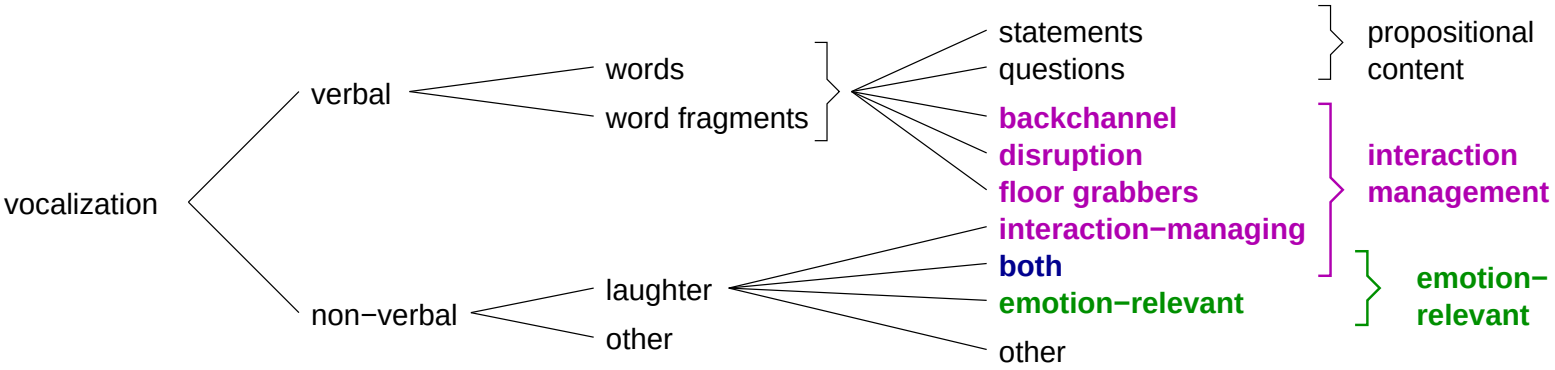

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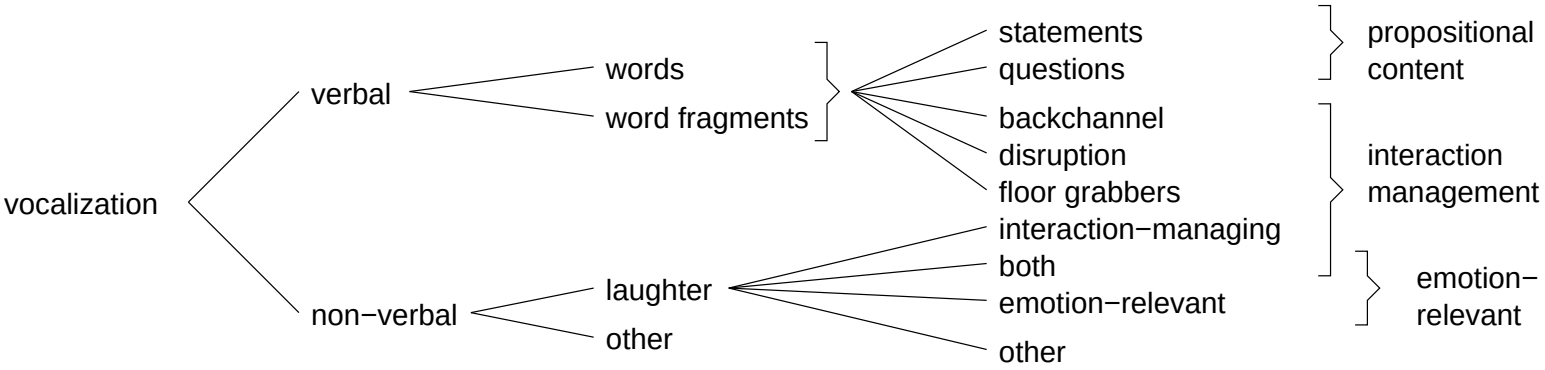

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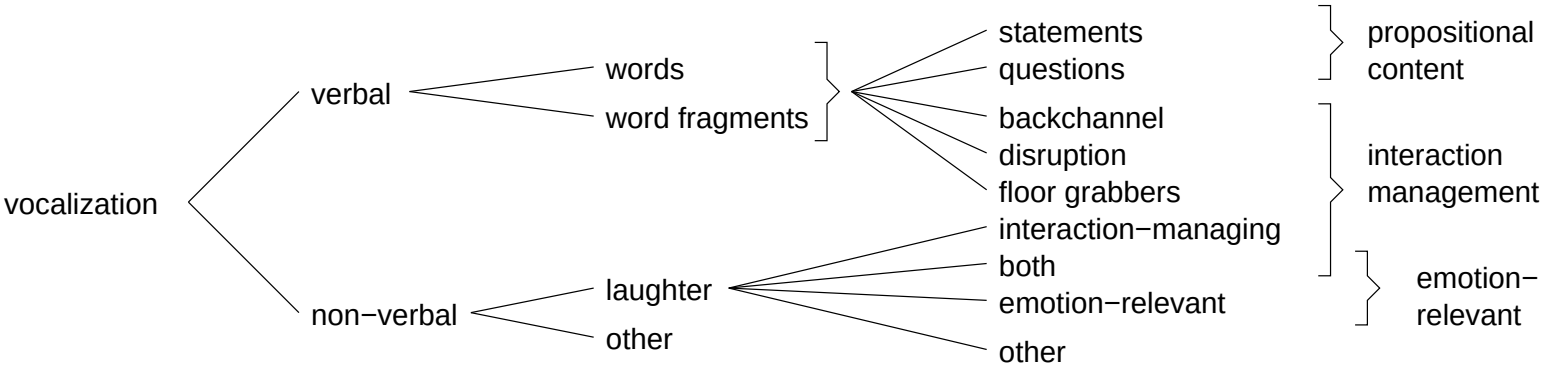

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- given a speech corpus genre, it is generally not known
  1. how much laughter there actually is
  2. when it tends to occur

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4. How **robust** are our findings regarding laughter in meetings?
5. How do corpus types differentiate with respect to laughter?

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$\mathcal{S}/\mathcal{L}$ islands	contiguous per-group intervals in which at least one participant talks/laughs

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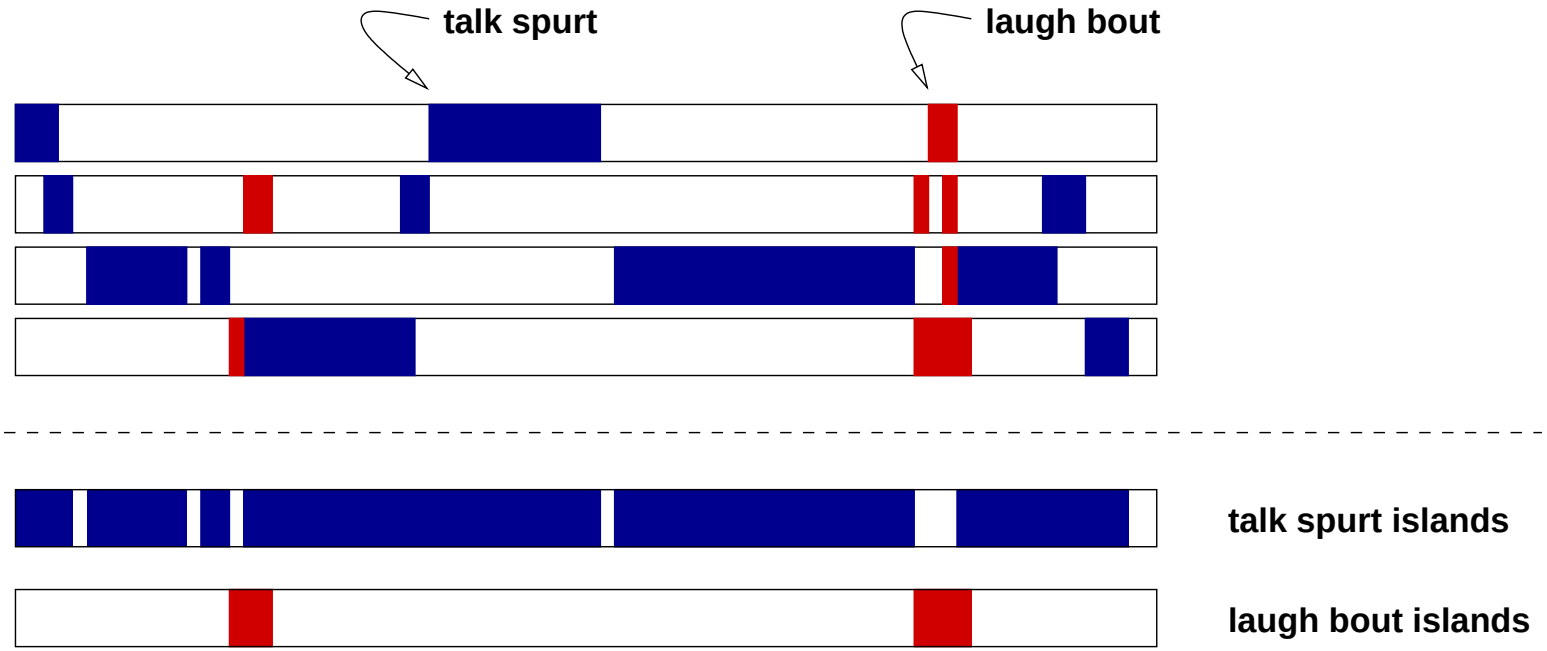

Outline of Talk

1. Motivation
2. The CHIL06 Seminar Corpus
3. Analysis
   1. Quantity (3 slides)
   2. Duration (2 slides)
   3. Overlap (3 slides)
   4. Dynamics of Overlap (2 slides)
4. Conclusions

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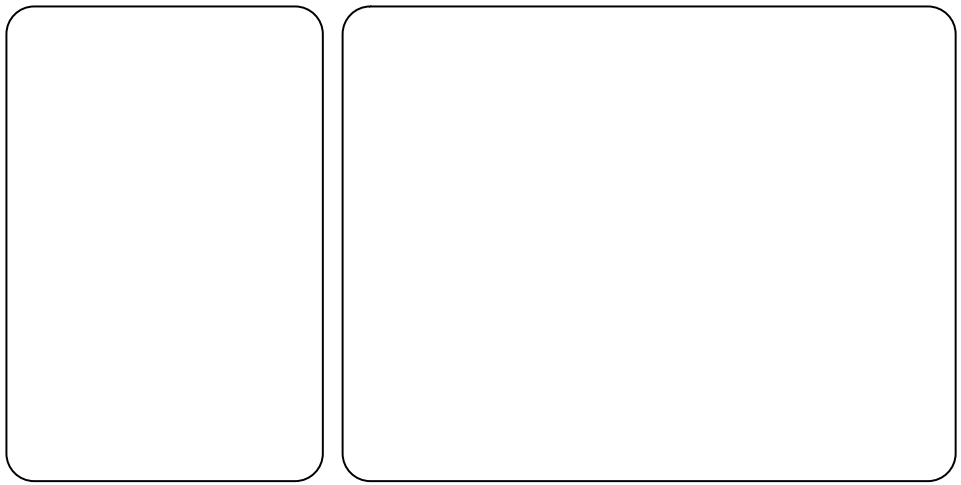
- collected to support major evaluations:
  - NIST Rich Transcription (RT) Meeting Recogntion
  - Classification of Events, Activities and Relationships (CLEAR)

NIST RT07s Corpus Split

CHIL06
785 minutes

NIST RT07s Corpus Split



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CHIL06_2
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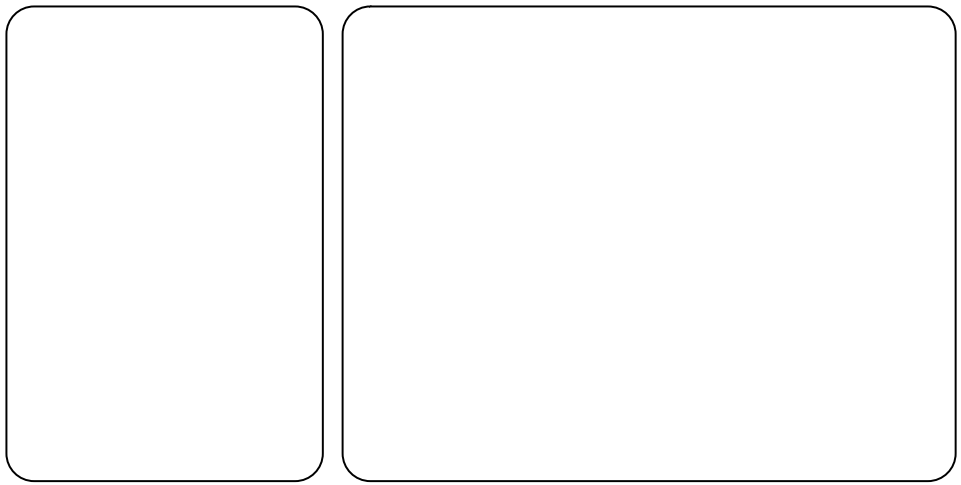

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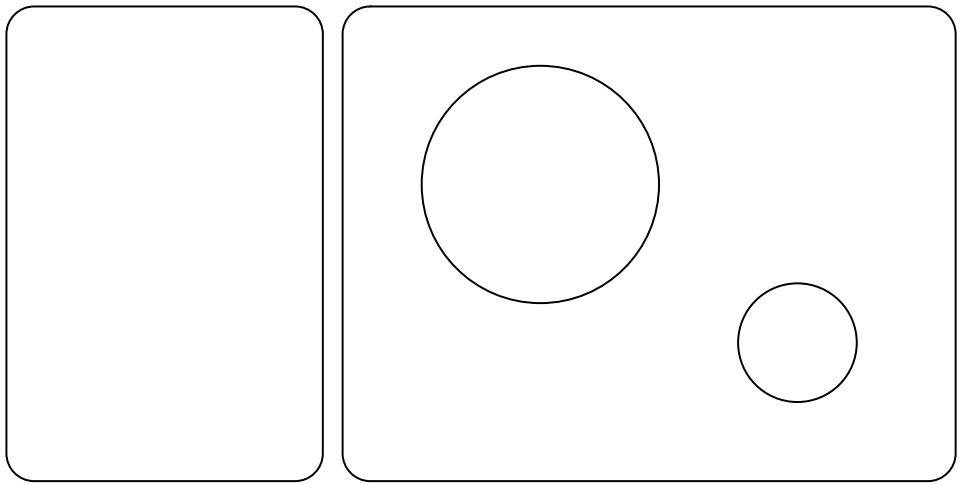

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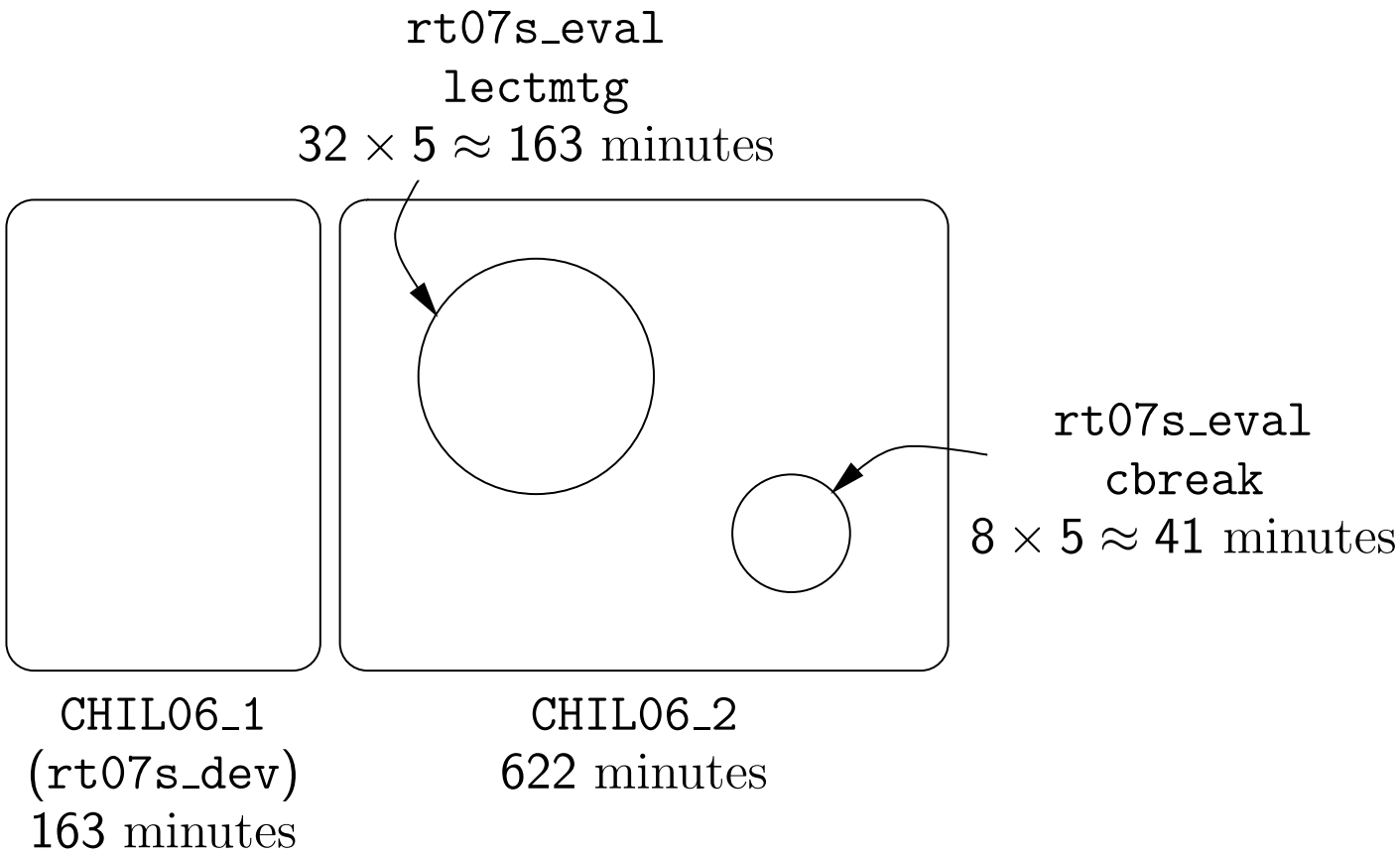

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- for each participant j, $1 \leq j \leq J \equiv 71$:
  - for each seminar r, $1 \leq r \leq R \equiv 25$:
    - $T_{\mathcal{L}_V}^{r,j}$: voiced-laugh-time
    - $T_{\mathcal{L}_U}^{r,j}$: unvoiced-laugh-time
    - $T_{\mathcal{L}}^{r,j} = T_{\mathcal{L}_V}^{r,j} + T_{\mathcal{L}_U}^{r,j}$: laugh-time
    - $T_{\mathcal{S}}^{r,j}$: talk-time
    - $T_{\mathcal{V}}^{r,j}$: vocalization-time
    - NOTE: $T_{\mathcal{S}}^{r,j} + T_{\mathcal{L}}^{r,j} > T_{\mathcal{V}}^{r,j}$, because $\mathcal{S} \cap \mathcal{L} \neq \emptyset$
    - $T^{r,j} \equiv T^{r}$: participation-time

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    - $T^{r,j} \equiv T^{r}$: participation-time
- $T_{\mathcal{V}_V} = \sum_{j=1}^{J} \sum_{r=1}^{R} T_{\mathcal{L}_V}^{r,j} =$ 37.2 minutes

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    - $T_{\mathcal{L}}^{r,j} = T_{\mathcal{L}_V}^{r,j} + T_{\mathcal{L}_U}^{r,j}$: laugh-time
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    - $T^{r,j} \equiv T^{r}$: participation-time
- $T_{\mathcal{V}_V} = \sum_{j=1}^{J} \sum_{r=1}^{R} T_{\mathcal{L}_V}^{r,j} =$ 37.2 minutes
- $T_{\mathcal{V}_U} = \sum_{j=1}^{J} \sum_{r=1}^{R} T_{\mathcal{L}_U}^{r,j} =$ 8.4 minutes

Speech vs Laughter by Time, **by Participant**

- for every participant j, $1 \leq j \leq J$, proportion of participation time spent on producing vocalization type α

$$p_{\alpha}^{j} = \frac{\sum_{r=1}^{R} T_{\alpha}^{r,j}}{\sum_{r=1}^{R} T^{r,j}}$$

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  - unvoiced laughter, $\alpha = \mathcal{L}_U$

Speech vs Laughter by Time, **by Participant**

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  - unvoiced laughter, $\alpha = \mathcal{L}_U$
  - all vocalization, $\alpha = \mathcal{V} = \mathcal{S} \cup \mathcal{L}$

Speech vs Laughter by Time, **by Participant**

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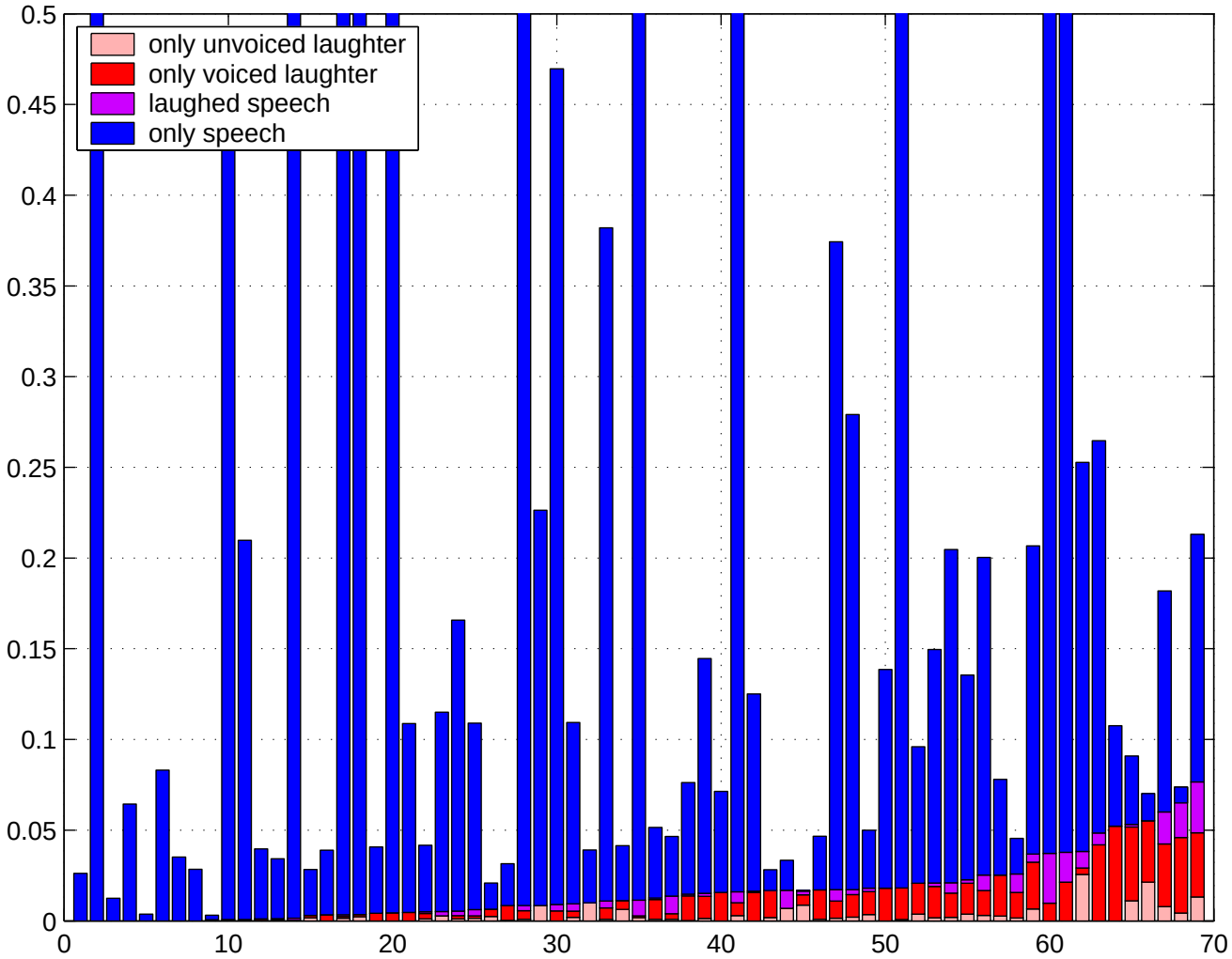
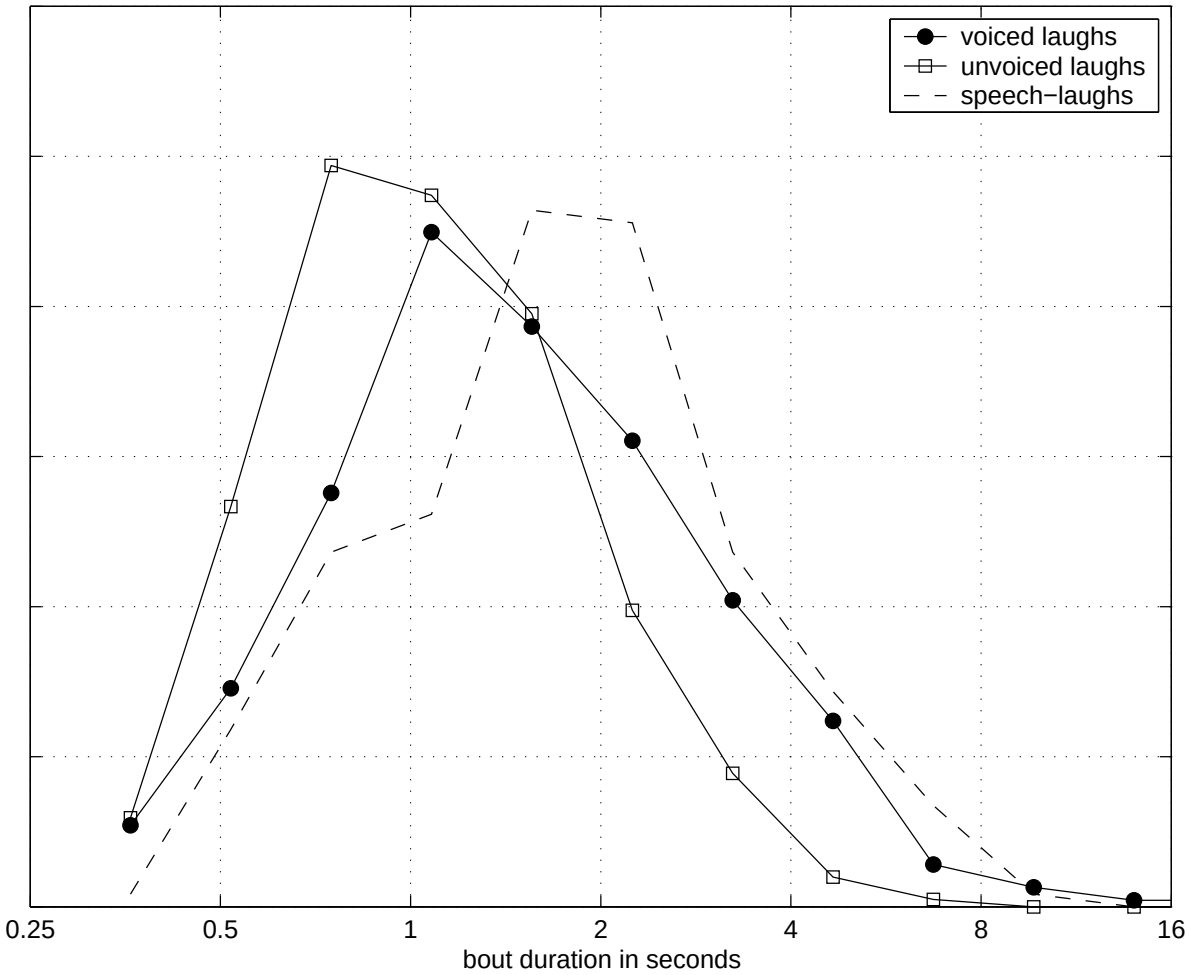
  - voiced laughter excluding "laughed speech", $\alpha = \mathcal{L}_V - \mathcal{S} \cap \mathcal{L}$
  - unvoiced laughter, $\alpha = \mathcal{L}_U$
  - all vocalization, $\alpha = \mathcal{V} = \mathcal{S} \cup \mathcal{L}$
  - NOTE: $p_{\mathcal{V}}^j = p_{\mathcal{S}^j \cap \mathcal{L}}^j + p_{\mathcal{S} - \mathcal{S} \cap \mathcal{L}}^j + p_{\mathcal{L}_V - \mathcal{S} \cap \mathcal{L}}^j + p_{\mathcal{L}_U}^j$

Speech vs Laughter by Time, **by Participant**: Results

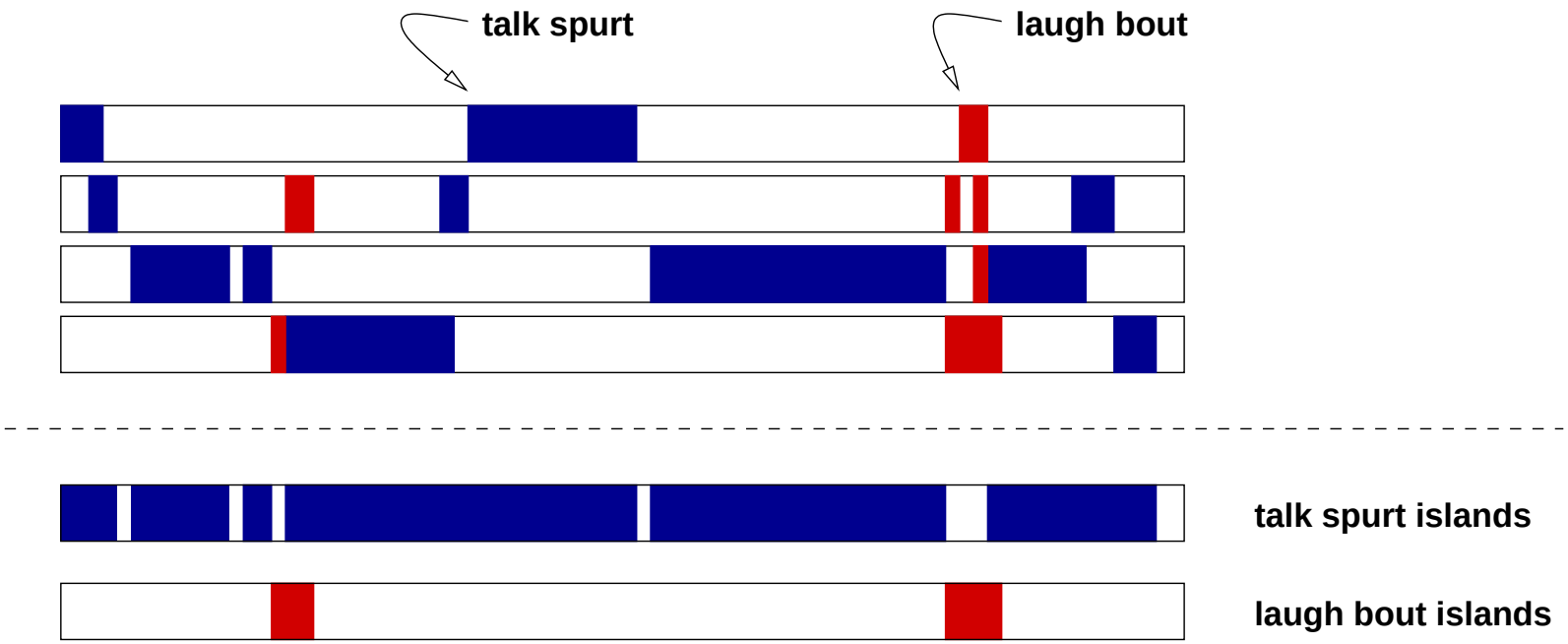


Bout Duration, by Type

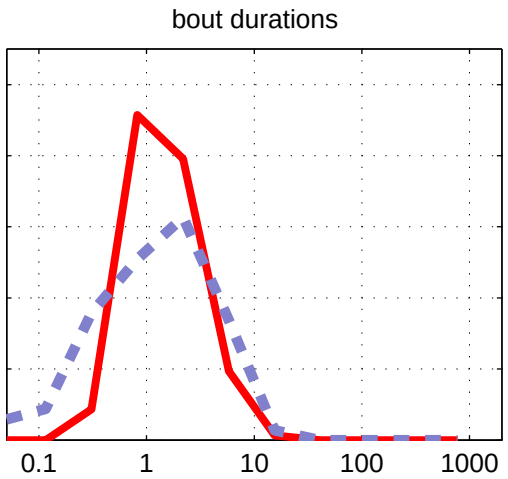


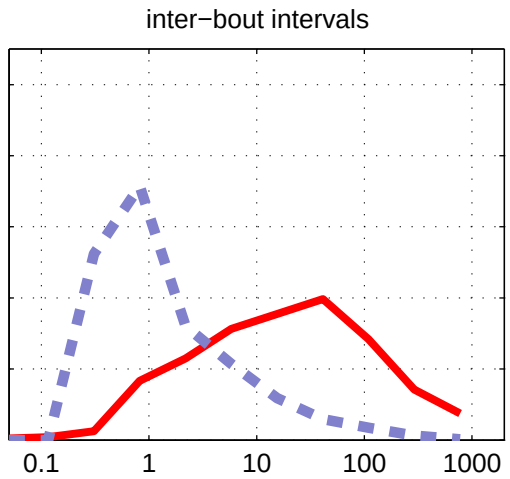
Inter-Bout and Inter-Island Durations (seconds)

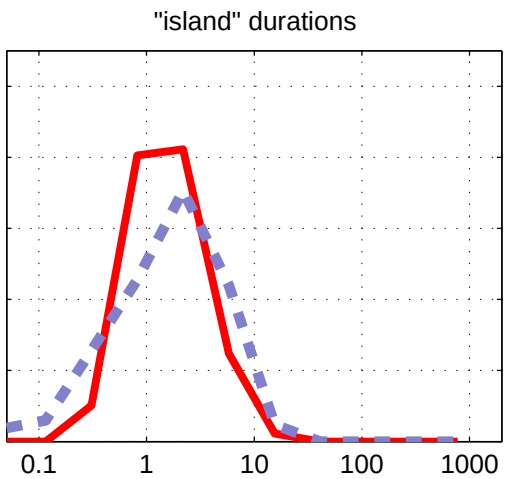
Recall:

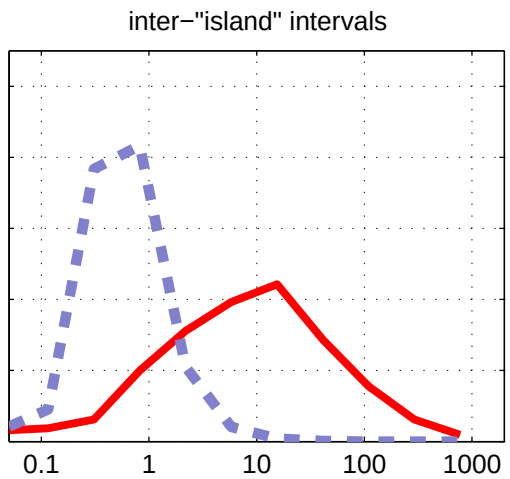


Inter-Bout and Inter-Island Durations (seconds)









Overlap

- (recall) $T_{\alpha}^{r,j}$: total duration of all bouts/spurts of j in r

Overlap

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- (define) $T_{\alpha}^{r,*}$: total duration of all bout/spurt islands in r

Overlap

- (recall) $T_\alpha^{r,j}$: total duration of all bouts/spurts of j in r
- (define) $T_\alpha^{r,*}$: total duration of all bout/spurt islands in r
- for the whole corpus of R seminars,

$$\text{duration of all bouts/spurts } T_\alpha = \sum_{r=1}^{R} \sum_{j=1}^{J} T_\alpha^{r,j}$$

$$\text{duration of all bout/spurt islands } T_\alpha^* = \sum_{r=1}^{R} T_\alpha^{r,*}$$

$$\textbf{compression ratio } c_\alpha = \frac{T_\alpha}{T_\alpha^*}$$

Overlap: Results for `rt07s_dev` (163.1 min)

Vocalization Type α	T_α (min)	c_α	Proportion (in %) of T^*_α with n participants vocalizing simultaneously 1	2	3	$\geq$4
$\mathcal{S}$						
$\mathcal{L}$ $\mathcal{L}_V$ $\mathcal{L}_U$						
$\mathcal{S} \cup \mathcal{L}$ $\mathcal{S} \cap \mathcal{L}$						

Overlap: Results for rt07s_dev (163.1 min)

Vocalization Type α	T_α (min)	c_α	Proportion (in %) of T^*_α with n participants vocalizing simultaneously 1	2	3	≥4
$\mathcal{S}$	131.0	1.037	96.7	3.1	0.2	0.0
$\mathcal{L}$						
$\mathcal{L}_V$						
$\mathcal{L}_U$						
$\mathcal{S} \cup \mathcal{L}$						
$\mathcal{S} \cap \mathcal{L}$						

1. Speech ($\mathcal{S}$) exhibits relatively little overlap.

Overlap: Results for rt07s_dev (163.1 min)

Vocalization Type α	T_α (min)	c_α	Proportion (in %) of T^*_α with n participants vocalizing simultaneously 1	2	3	≥4
$\mathcal{S}$	131.0	1.037	96.7	3.1	0.2	0.0
$\mathcal{L}$	5.1	1.5	64.0	25.3	9.5	1.2
$\mathcal{L}_V$						
$\mathcal{L}_U$						
$\mathcal{S} \cup \mathcal{L}$						
$\mathcal{S} \cap \mathcal{L}$						

2. In contrast, laughter ($\mathcal{L}$) exhibits a lot.

Overlap: Results for rt07s_dev (163.1 min)

Vocalization Type α	T_α (min)	c_α	Proportion (in %) of T^*_α with n participants vocalizing simultaneously 1	2	3	≥4
$\mathcal{S}$	131.0	1.037	96.7	3.1	0.2	0.0
$\mathcal{L}$	5.1	1.5	64.0	25.3	9.5	1.2
$\mathcal{L}_V$						
$\mathcal{L}_U$						
$\mathcal{S} \cup \mathcal{L}$	133.4	1.050	95.6	3.8	0.5	0.1
$\mathcal{S} \cap \mathcal{L}$	2.5	1.316	74.0	21.4	3.5	1.1

3. Approximately 50% of laughter is “laughed speech”.

Overlap: Results for rt07s_dev (163.1 min)

Vocalization Type α	T_α (min)	c_α	Proportion (in %) of T^*_α with n participants vocalizing simultaneously 1	2	3	≥4
$\mathcal{S}$	131.0	1.037	96.7	3.1	0.2	0.0
$\mathcal{L}$	5.1	1.5	64.0	25.3	9.5	1.2
$\mathcal{L}_V$	4.5	1.45	63.6	27.2	8.0	1.2
$\mathcal{L}_U$						
$\mathcal{S} \cup \mathcal{L}$	133.4	1.050	95.6	3.8	0.5	0.1
$\mathcal{S} \cap \mathcal{L}$	2.5	1.316	74.0	21.4	3.5	1.1

4. Approximately 90% of laughter is voiced; lots of overlap.

Overlap: Results for rt07s_dev (163.1 min)

Vocalization Type α	T_α (min)	c_α	Proportion (in %) of T^*_α with n participants vocalizing simultaneously 1	2	3	$\geq$4
$\mathcal{S}$	131.0	1.037	96.7	3.1	0.2	0.0
$\mathcal{L}$	5.1	1.5	64.0	25.3	9.5	1.2
$\mathcal{L}_V$	4.5	1.45	63.6	27.2	8.0	1.2
$\mathcal{L}_U$	0.5	1.0	100.0	0.0	0.0	0.0
$\mathcal{S} \cup \mathcal{L}$	133.4	1.050	95.6	3.8	0.5	0.1
$\mathcal{S} \cap \mathcal{L}$	2.5	1.316	74.0	21.4	3.5	1.1

5. Unvoiced laughter is never overlapped with itself.

Overlap: Results for `rt07s_eval::lectmtg` (163.6 min)

Vocalization Type α	T_α (min)	c_α	Proportion (in %) of T^*_α with n participants vocalizing simultaneously 1	2	3	≥4
$\mathcal{S}$	120.6	1.062	94.2	5.5	0.3	0.0
$\mathcal{L}$	13.6	1.462	66.5	24.0	6.9	2.6
$\mathcal{L}_V$	11.5	1.46	66.9	24.0	6.8	2.3
$\mathcal{L}_U$	2.0	1.05	95.0	5.0	0.0	0.0
$\mathcal{S} \cup \mathcal{L}$	132.8	1.127	89.6	8.5	1.4	0.5
$\mathcal{S} \cap \mathcal{L}$	1.4	1.077	95.7	4.3	0.0	0.0

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$\mathcal{S} \cap \mathcal{L}$	1.4	1.077	95.7	4.3	0.0	0.0

1. Speech ($\mathcal{S}$) exhibits little overlap (but more than `CHIL06_1`).

Overlap: Results for `rt07s_eval::lectmtg` (163.6 min)

Vocalization Type α	T_α (min)	c_α	Proportion (in %) of T^*_α with n participants vocalizing simultaneously 1	2	3	≥4
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$\mathcal{S} \cap \mathcal{L}$	1.4	1.077	95.7	4.3	0.0	0.0

2. Laughter ($\mathcal{L}$) exhibits lots.

Overlap: Results for `rt07s_eval::lectmtg` (163.6 min)

Vocalization Type α	T_α (min)	c_α	Proportion (in %) of T^*_α with n participants vocalizing simultaneously 1	2	3	≥4
$\mathcal{S}$	120.6	1.062	94.2	5.5	0.3	0.0
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$\mathcal{S} \cap \mathcal{L}$	1.4	1.077	95.7	4.3	0.0	0.0

3. Only 10% of laughter is “laughed speech”.

Overlap: Results for `rt07s_eval::lectmtg` (163.6 min)

Vocalization Type α	T_α (min)	c_α	Proportion (in %) of T^*_α with n participants vocalizing simultaneously 1	2	3	$\geq$4
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$\mathcal{S} \cap \mathcal{L}$	1.4	1.077	95.7	4.3	0.0	0.0

4. Approximately 85% of laughter is voiced; lots of overlap.

Overlap: Results for `rt07s_eval::lectmtg` (163.6 min)

Vocalization Type α	T_α (min)	c_α	Proportion (in %) of T^*_α with n participants vocalizing simultaneously 1	2	3	≥4
$\mathcal{S}$	120.6	1.062	94.2	5.5	0.3	0.0
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$\mathcal{S} \cap \mathcal{L}$	1.4	1.077	95.7	4.3	0.0	0.0

5. Unvoiced laughter **does** overlap with unvoiced laughter (rarely).

Overlap Dynamics: What happens once overlap exists?

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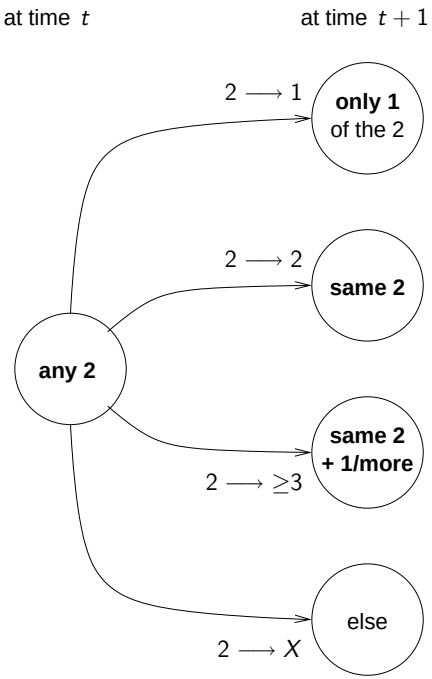
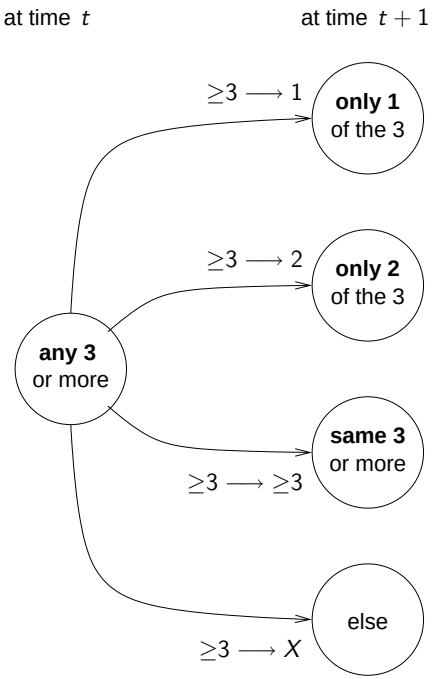


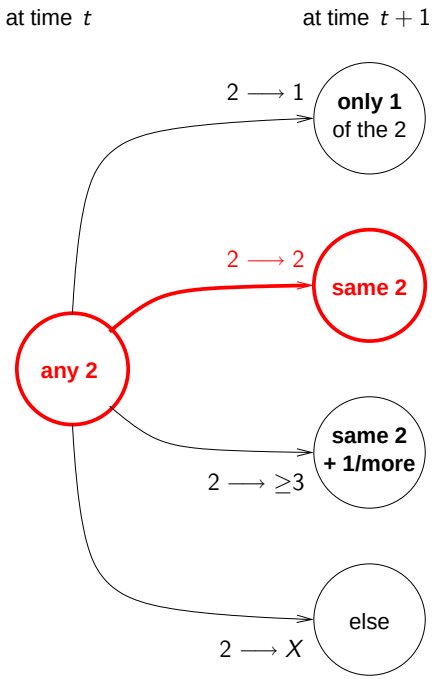
- once **2** participants vocalizing simultaneously?

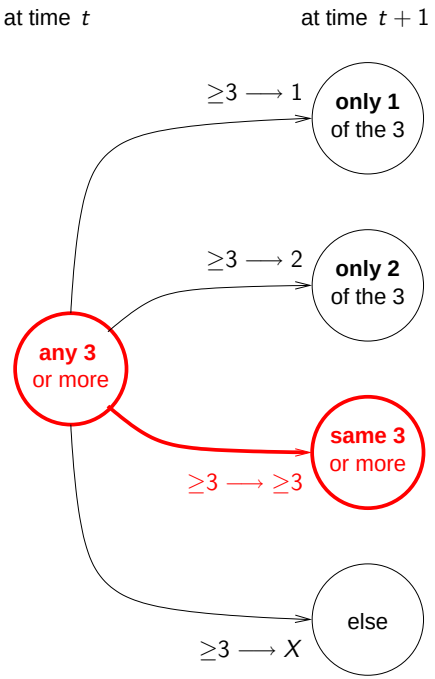
Overlap Dynamics: What happens once overlap exists?



- once **3 or more** participants vocalizing simultaneously?

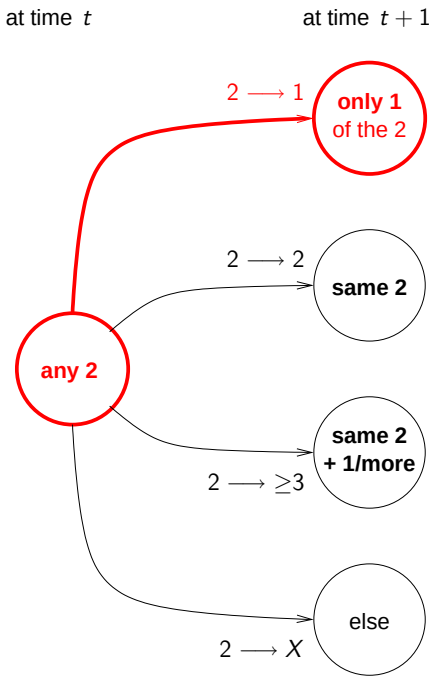
Overlap Dynamics: What happens once overlap exists?

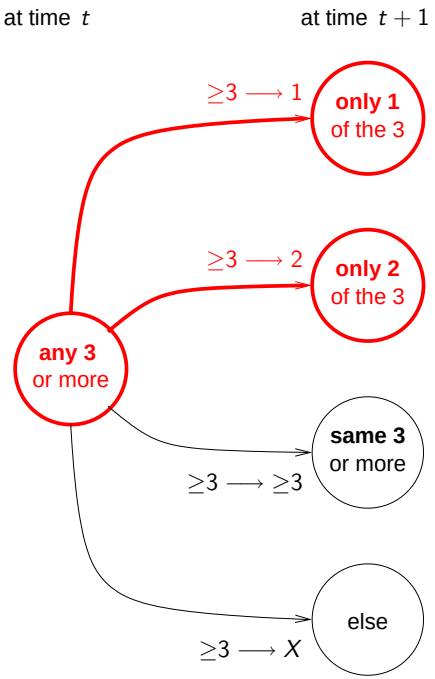




- what is the likelihood that overlap continue?

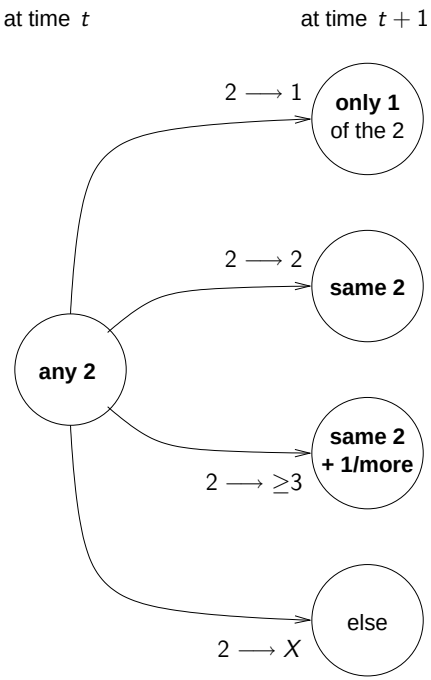
Overlap Dynamics: What happens once overlap exists?

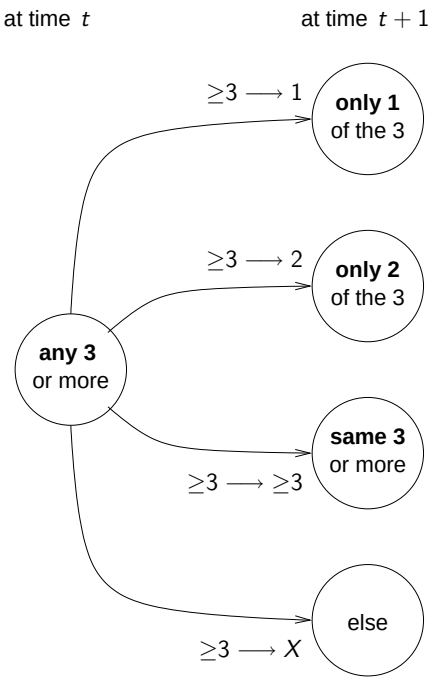




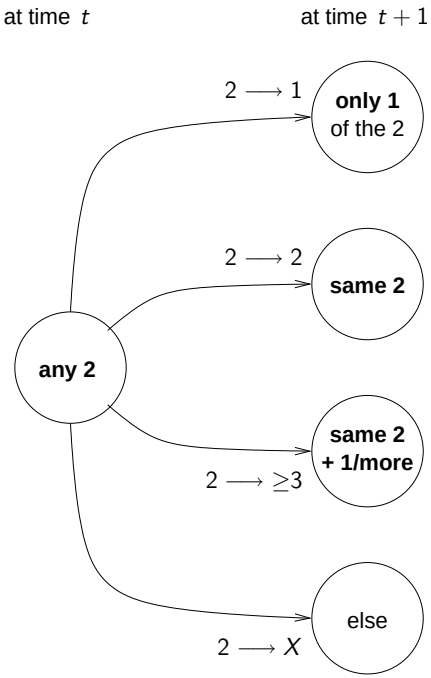
- what is the likelihood that overlap be resolved?

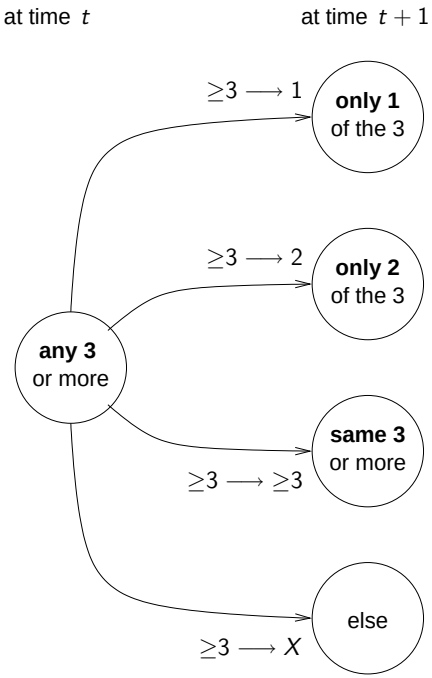
Overlap Dynamics: What happens once overlap exists?

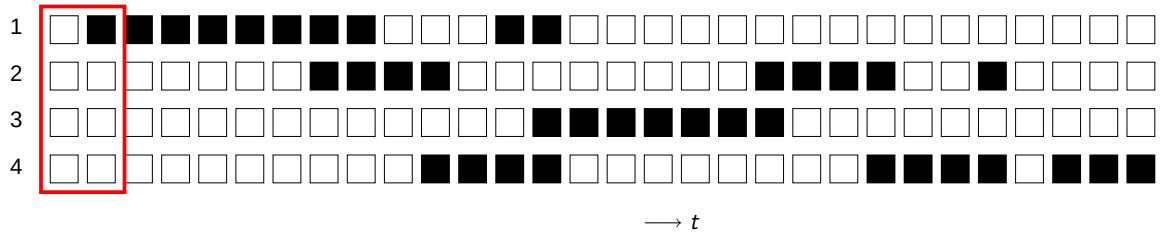




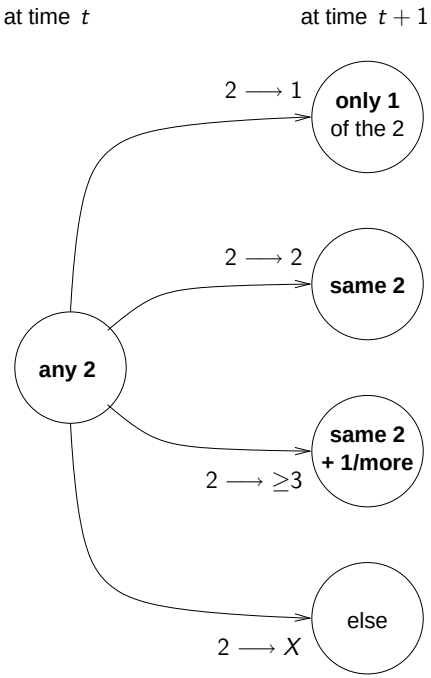
Overlap Dynamics: What happens once overlap exists?

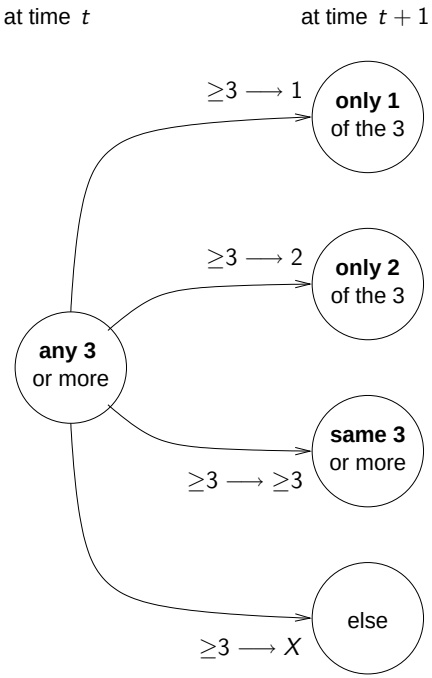


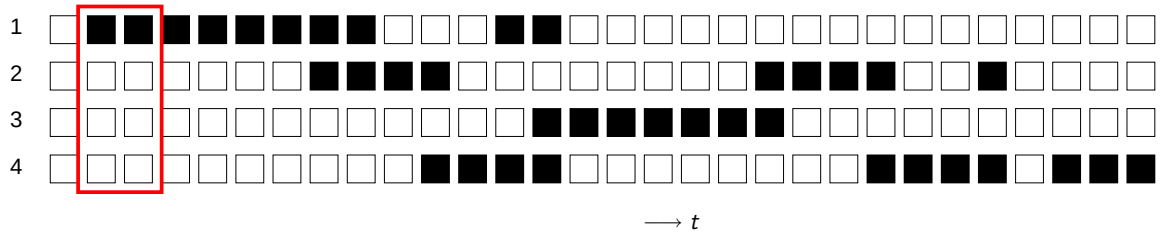




Overlap Dynamics: What happens once overlap exists?







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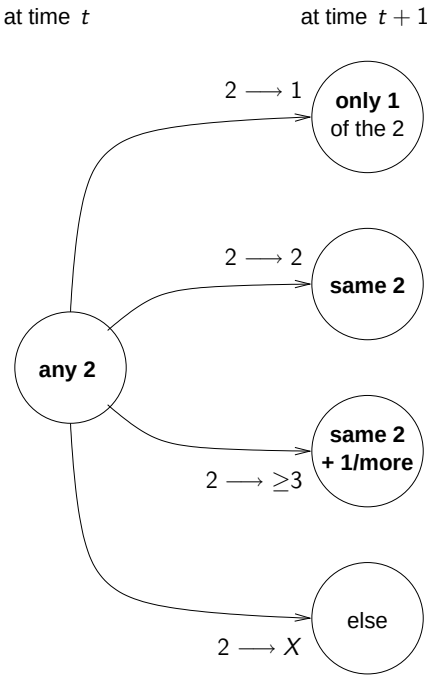

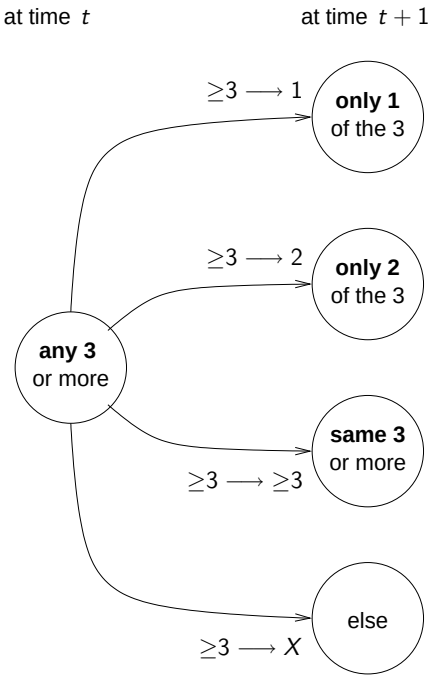

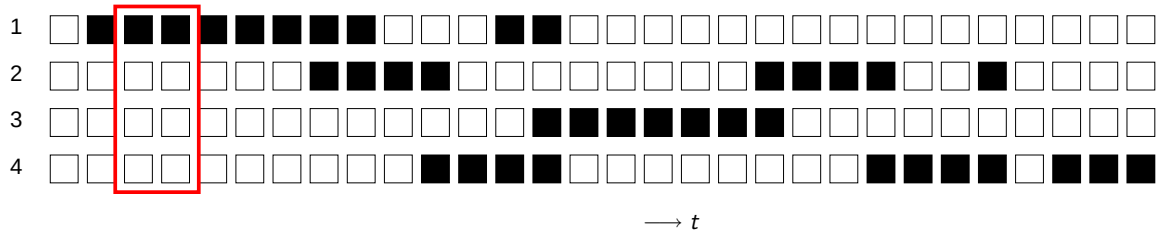

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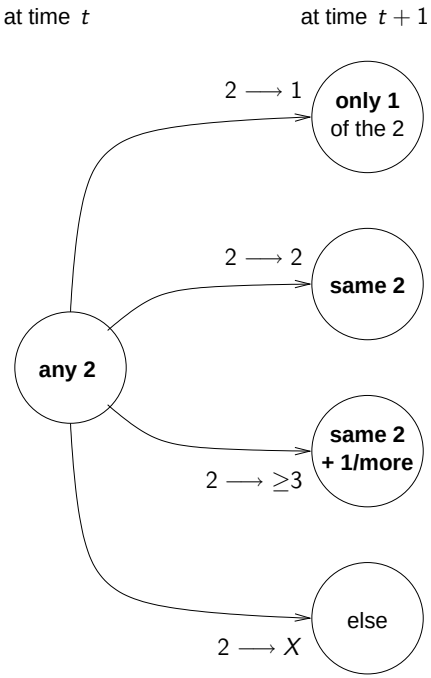

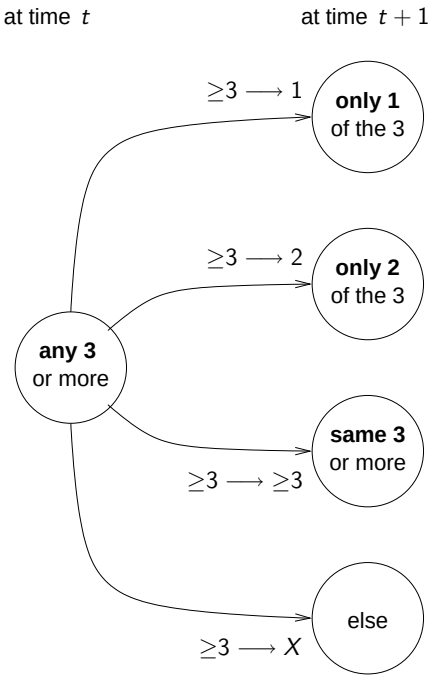

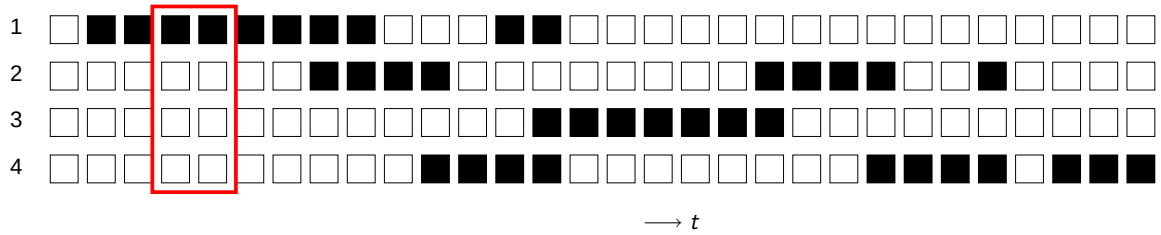

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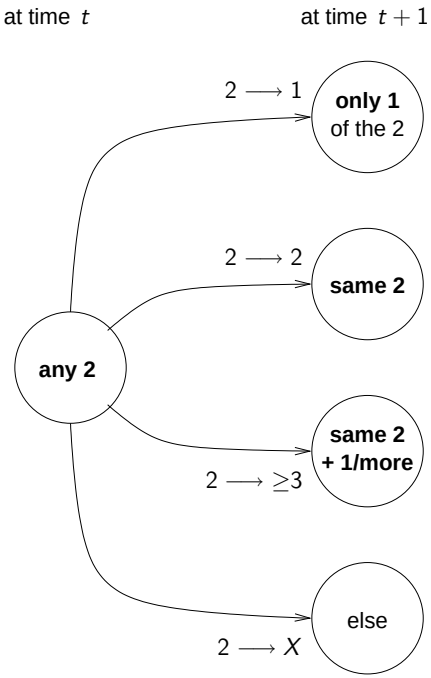

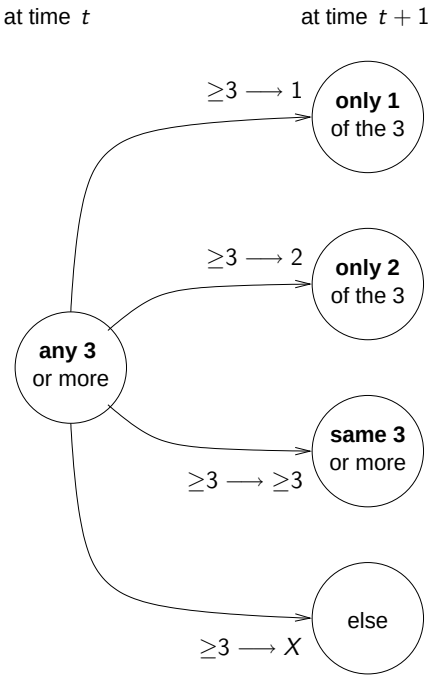

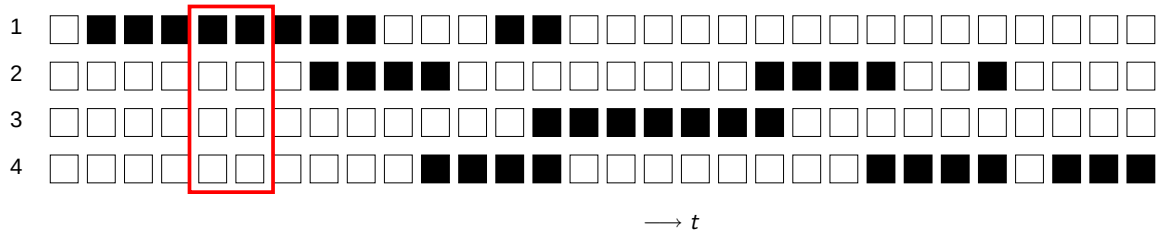

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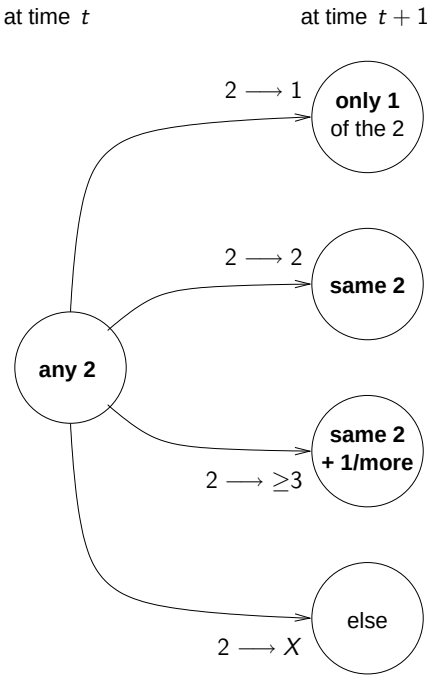

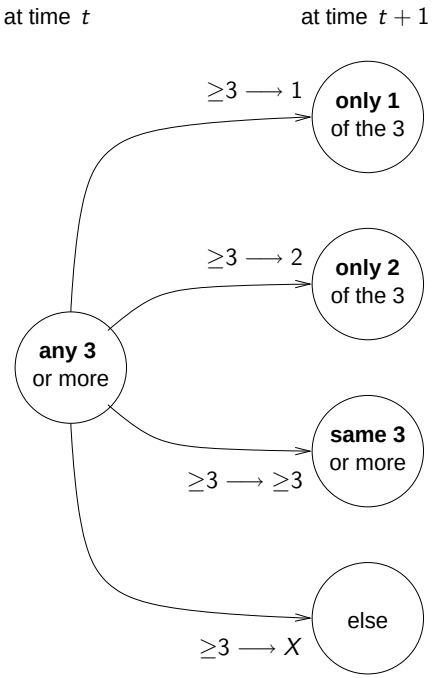

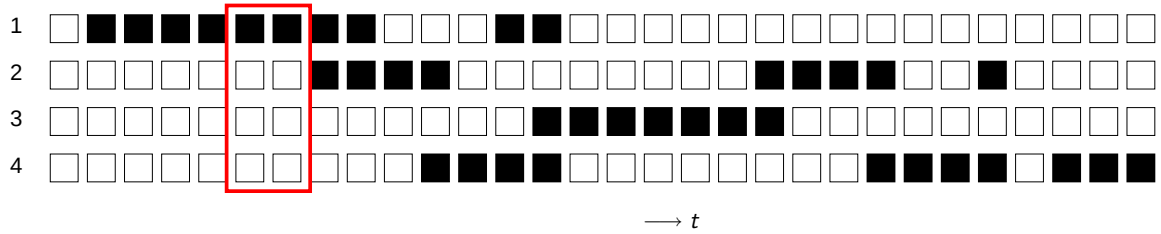

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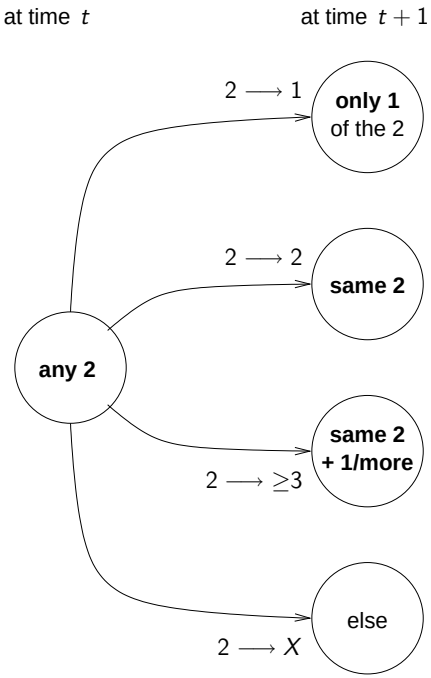

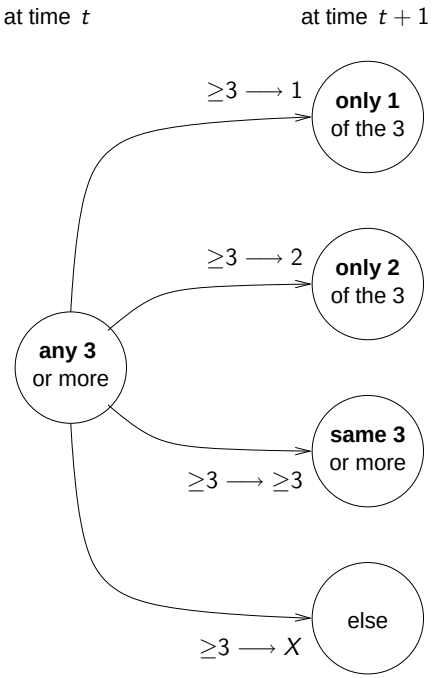

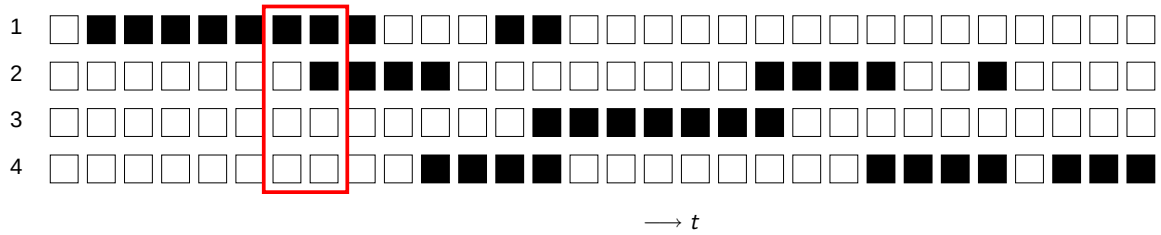

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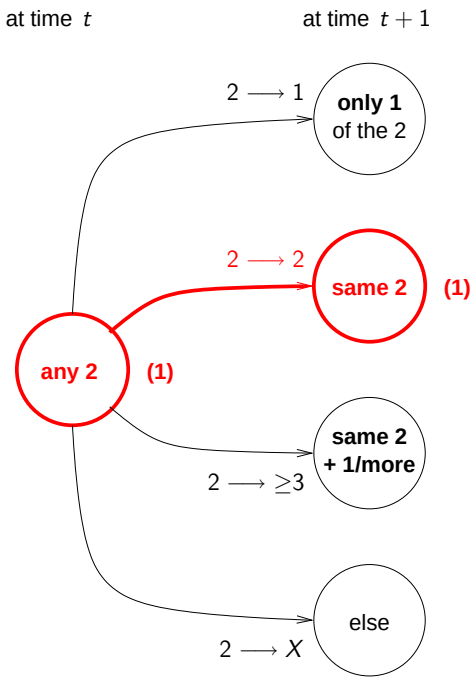

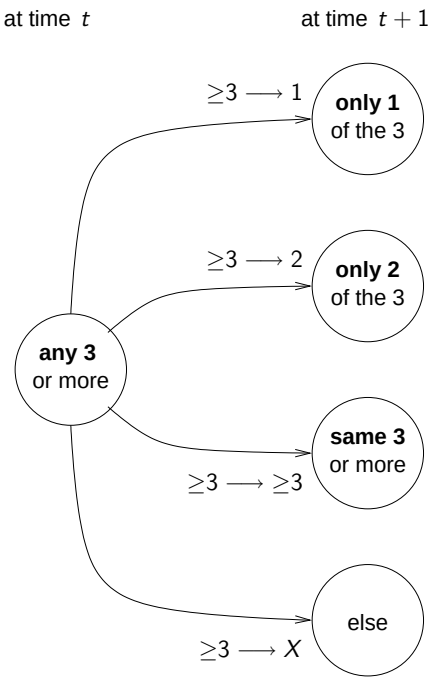

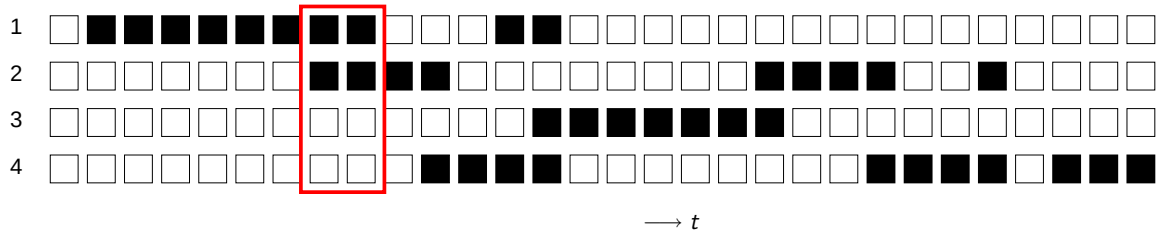

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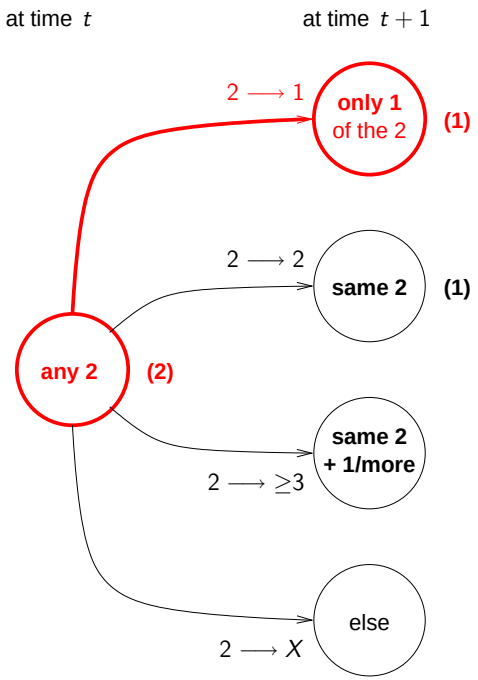

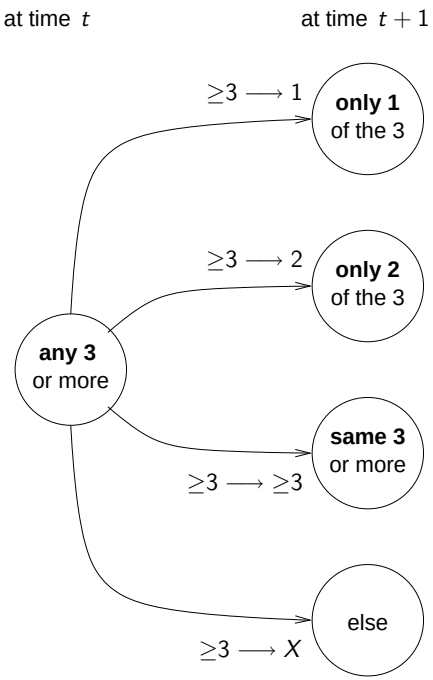

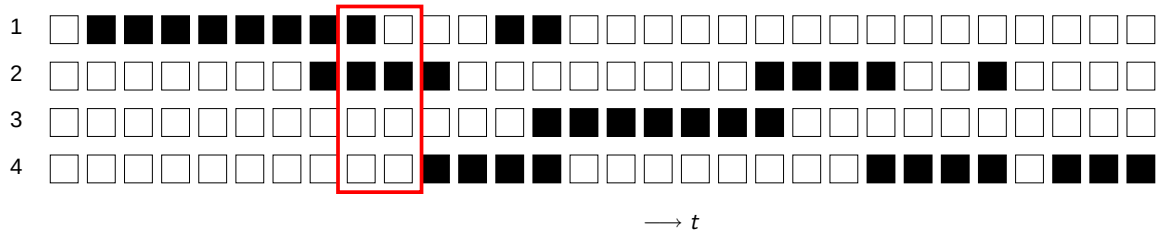

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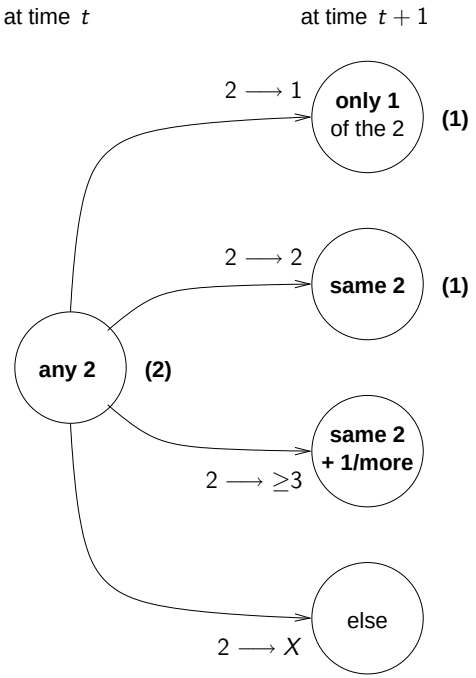

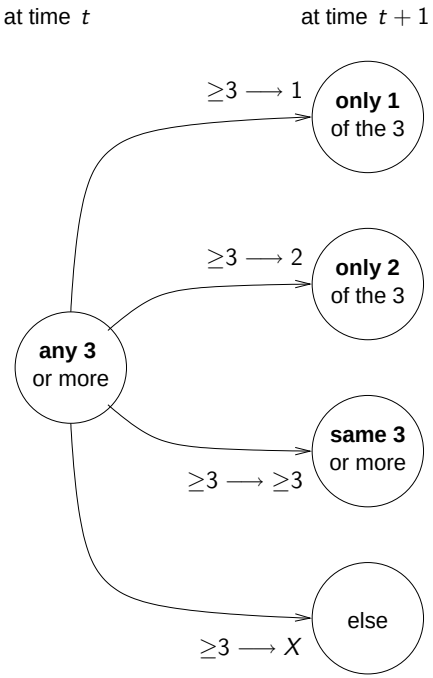

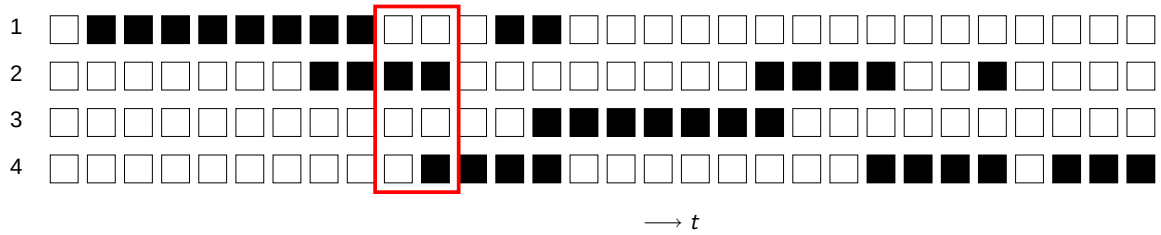

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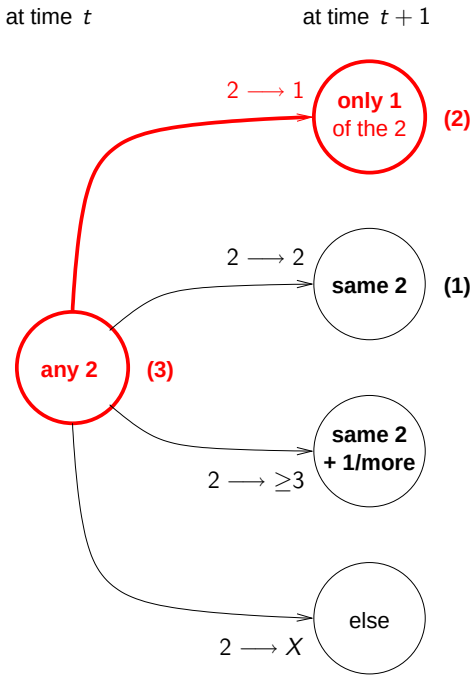

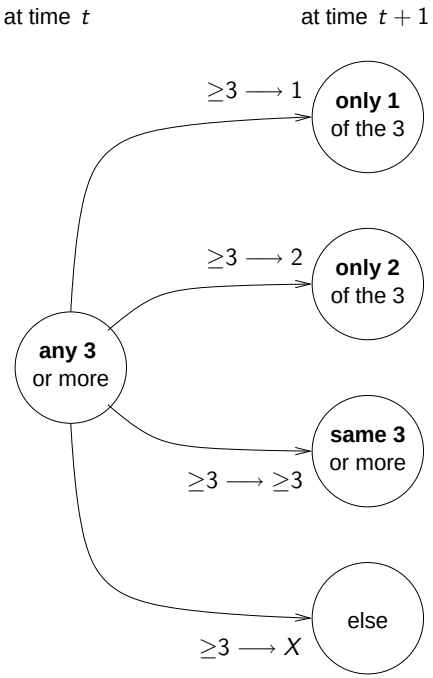

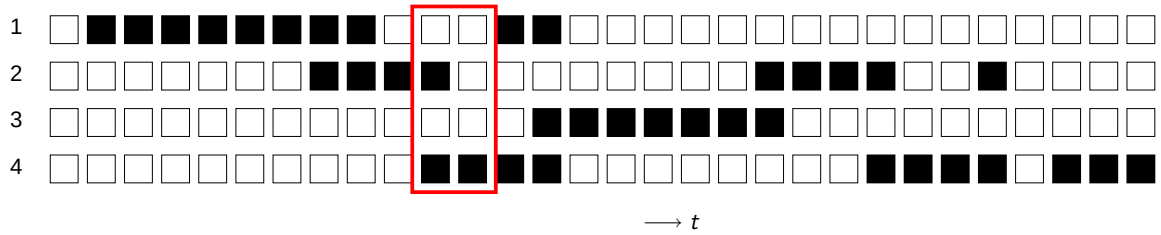

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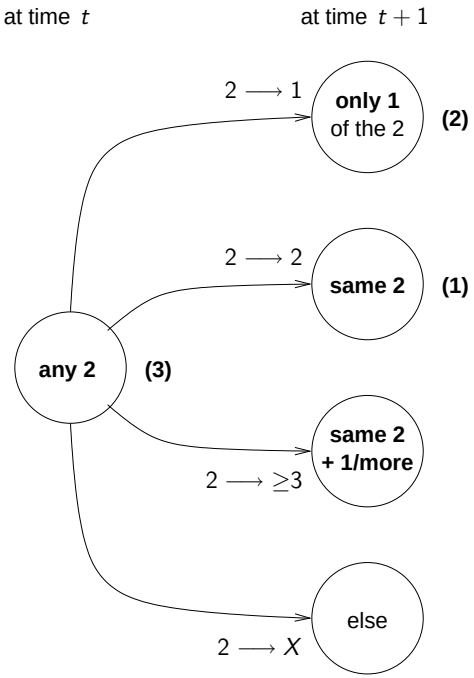

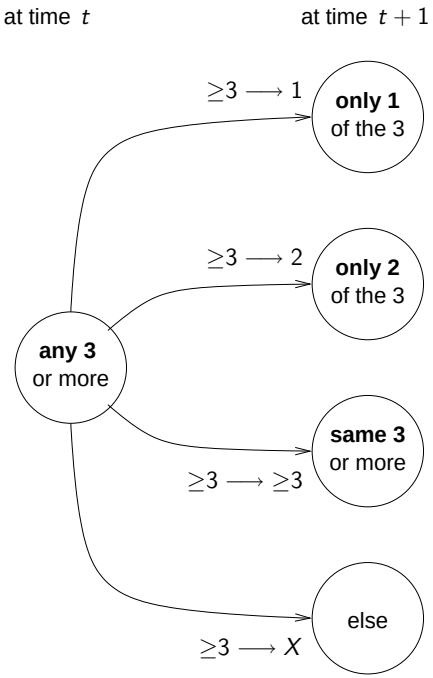

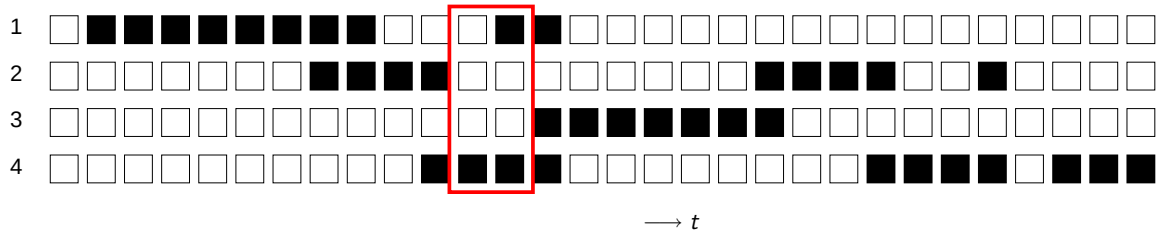

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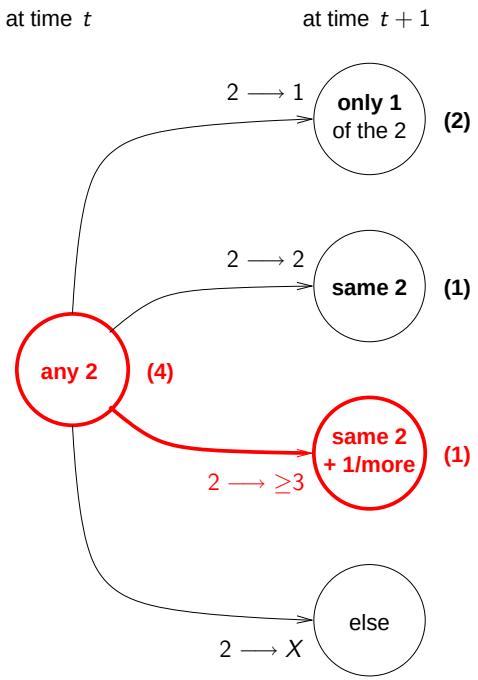

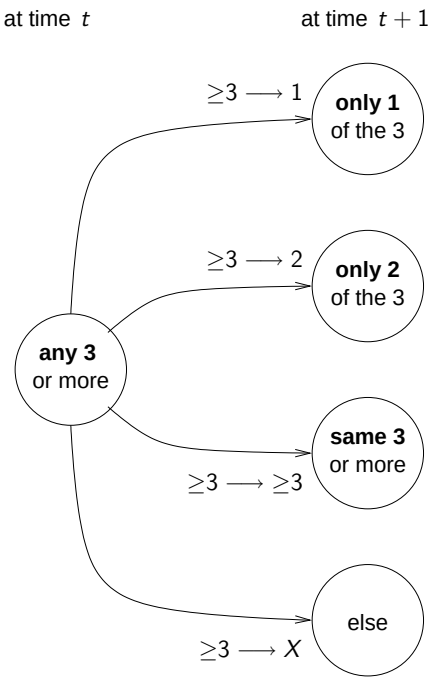

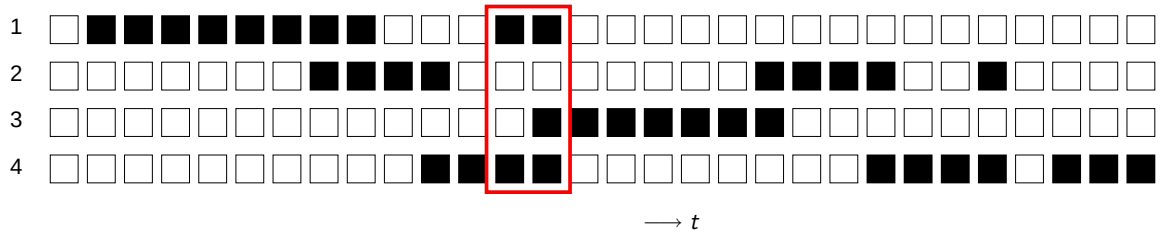

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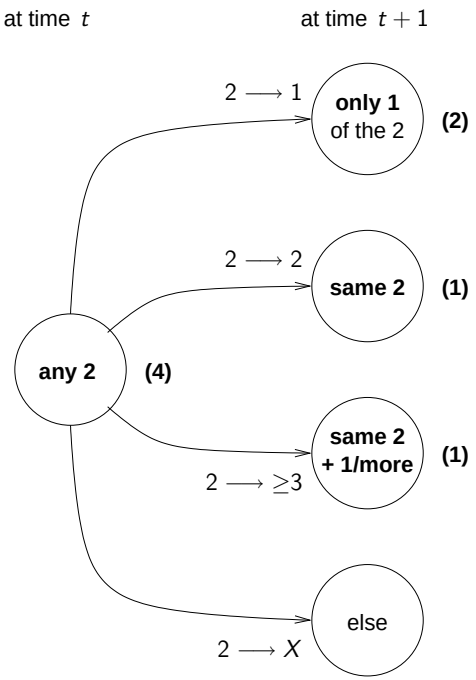

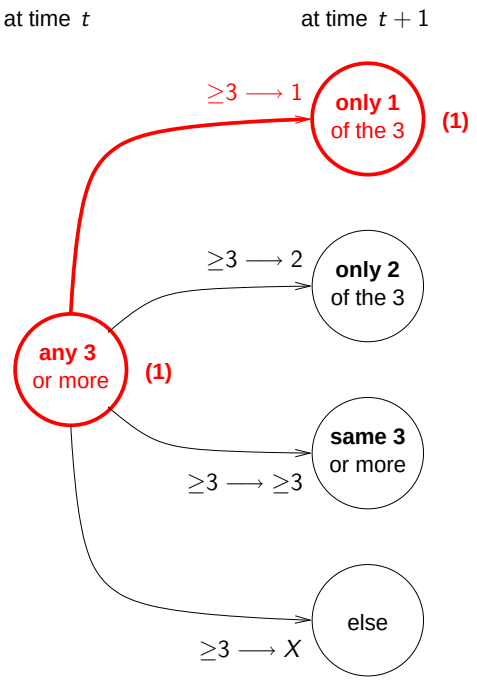

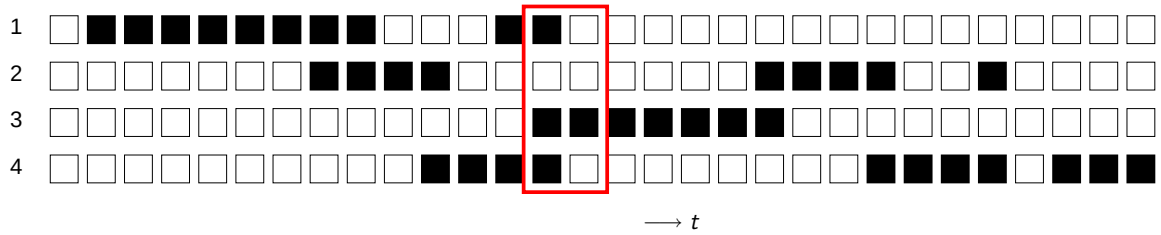

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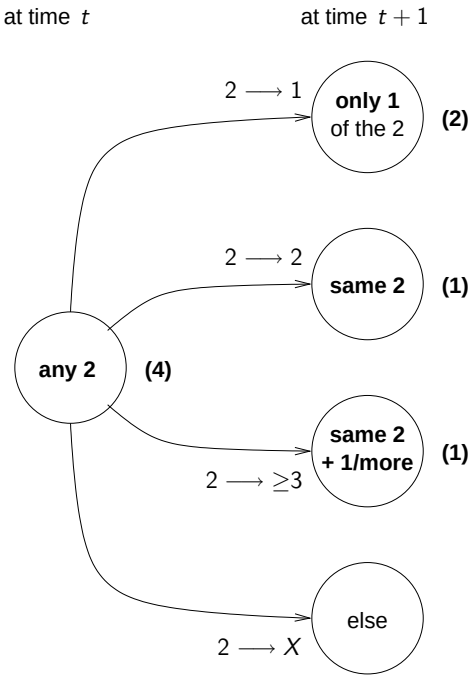

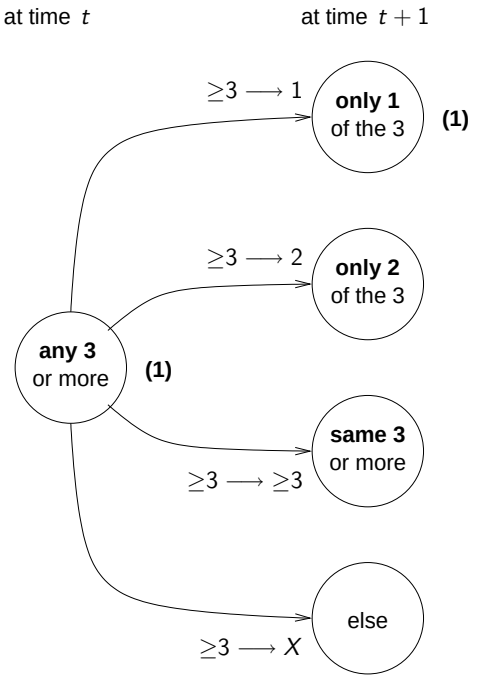

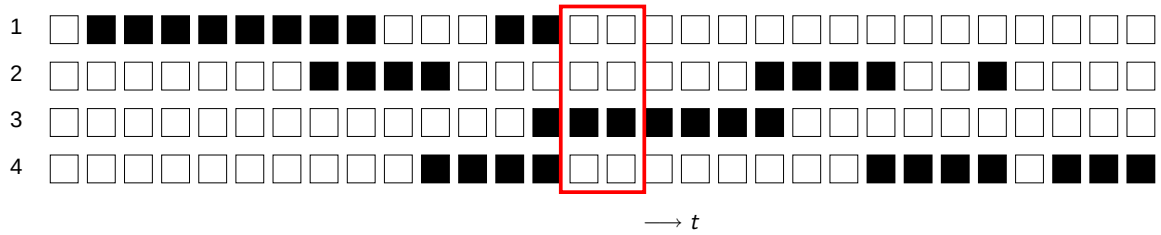

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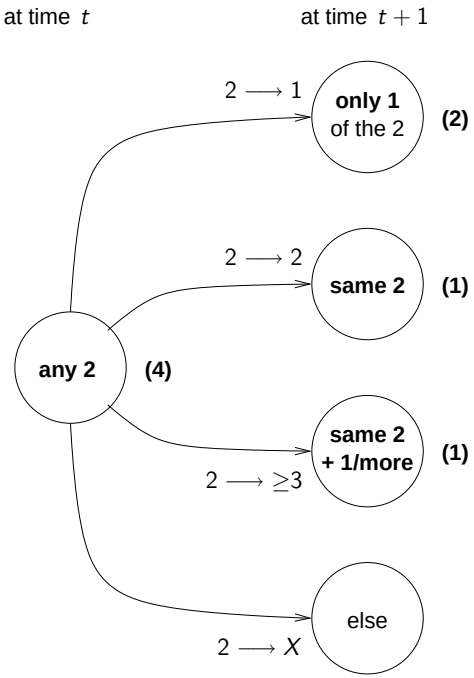

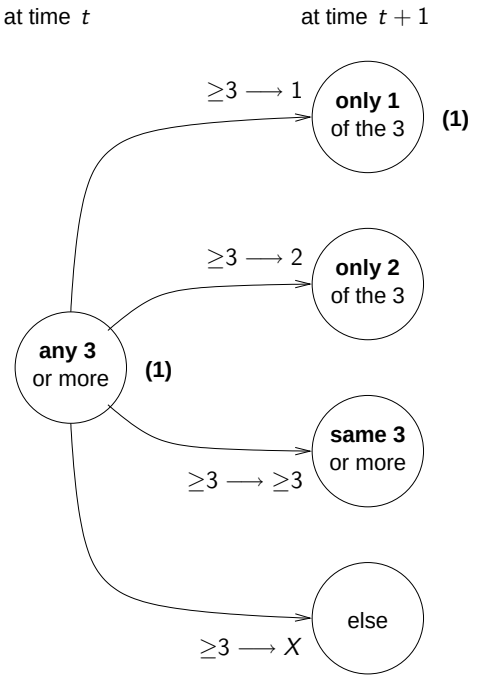

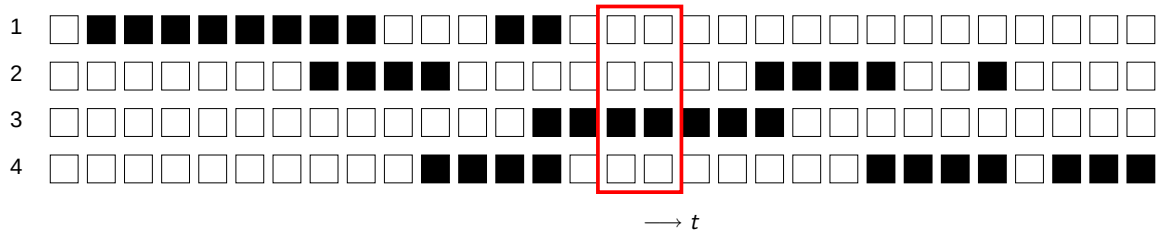

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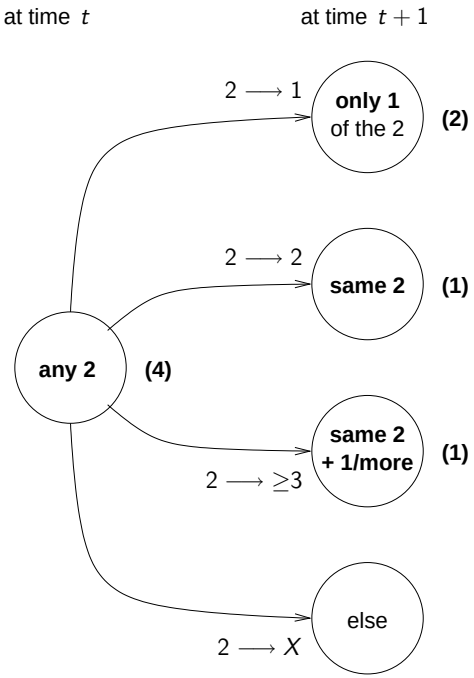

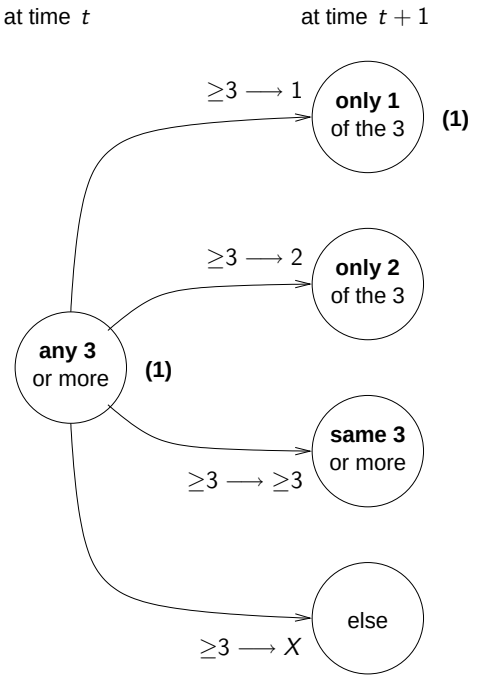

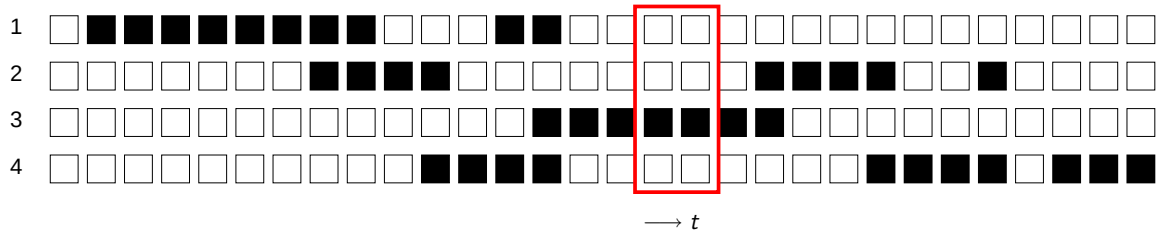

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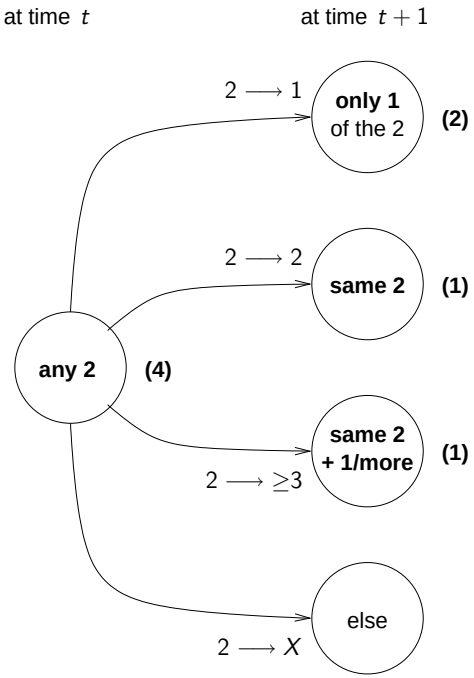

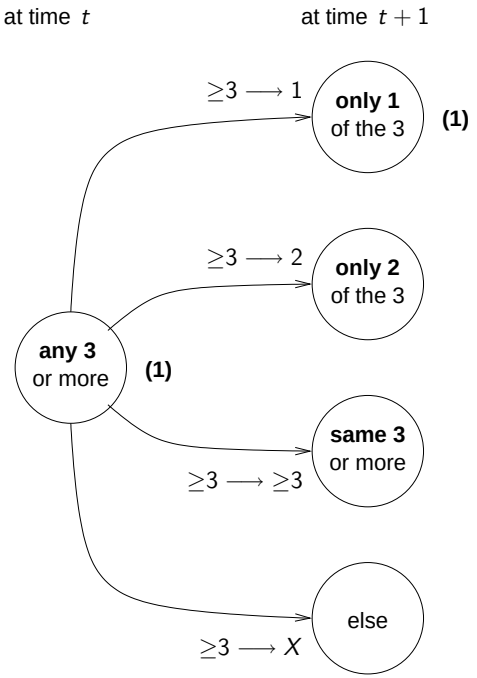

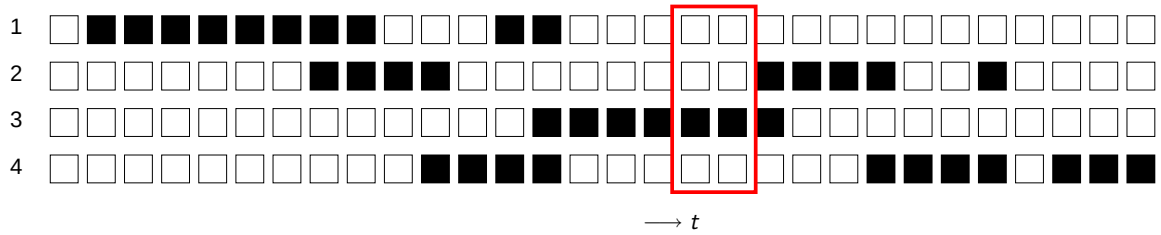

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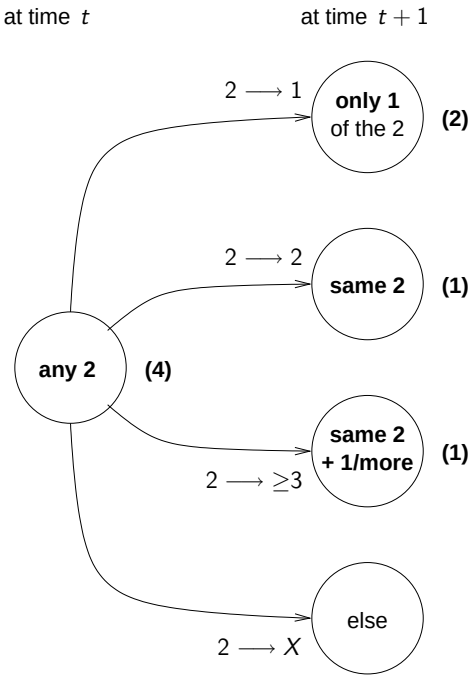

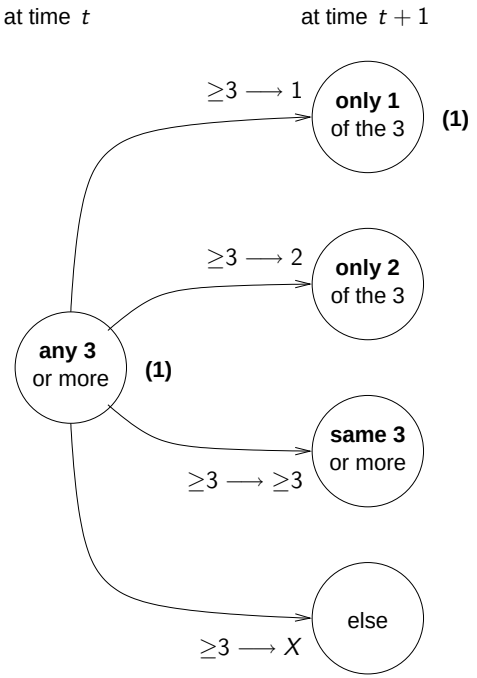

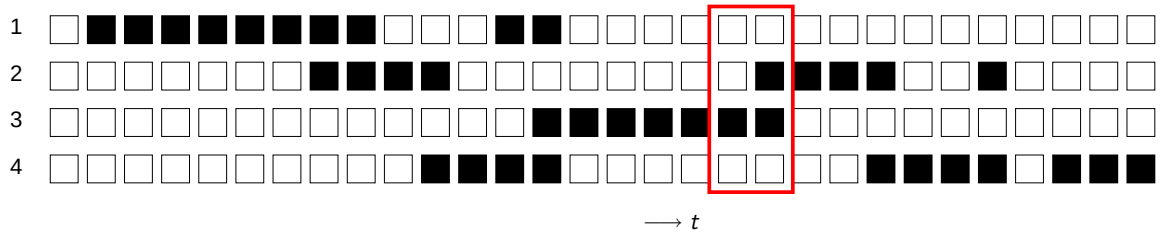

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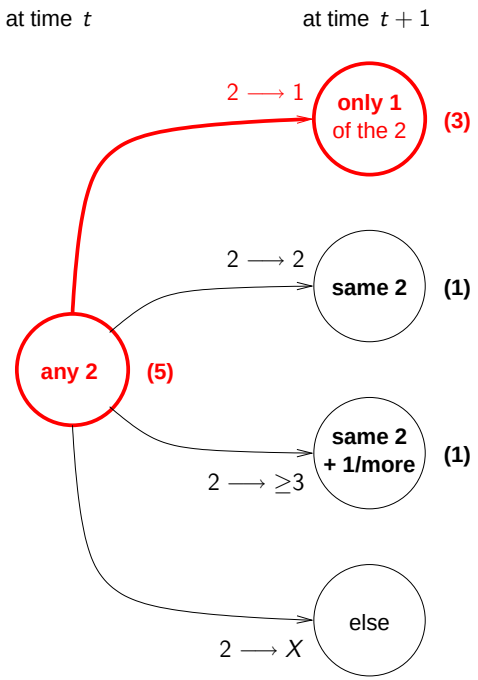

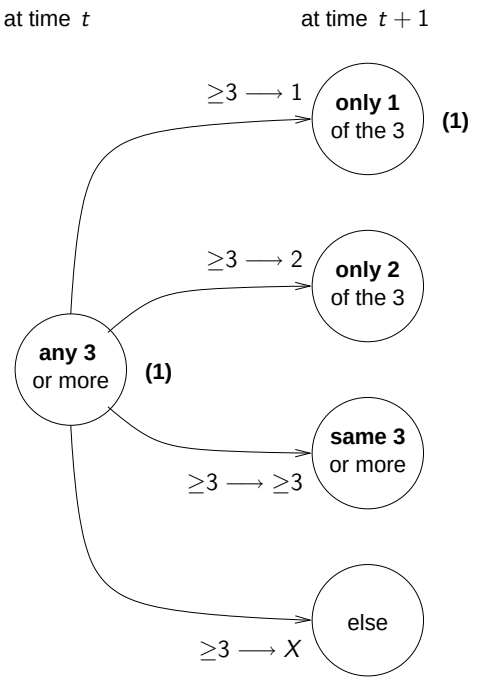

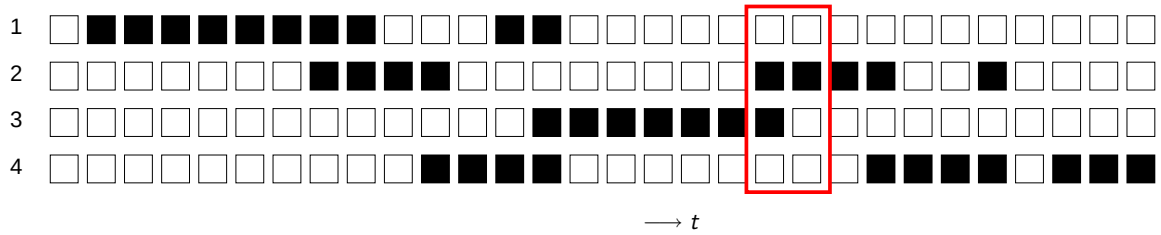

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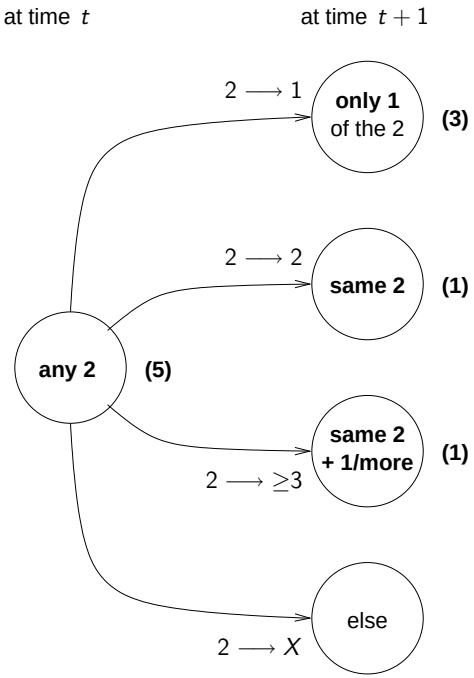

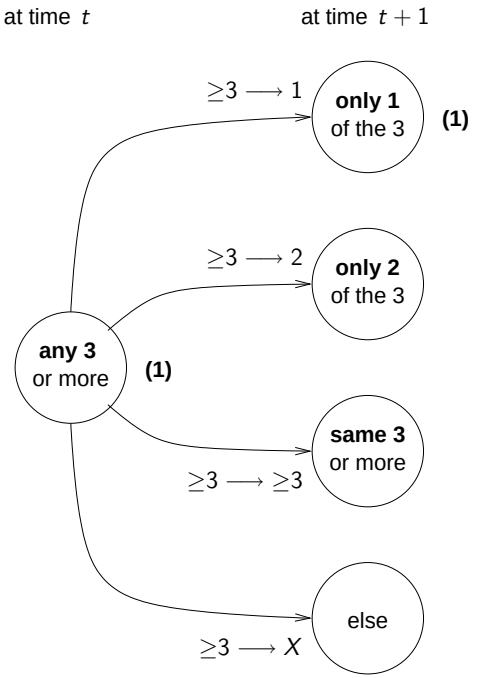

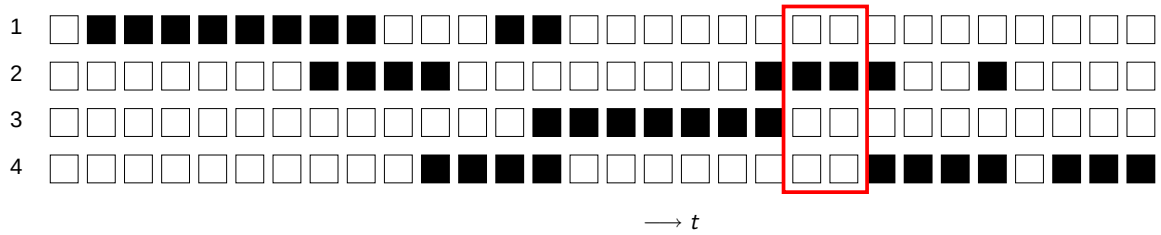

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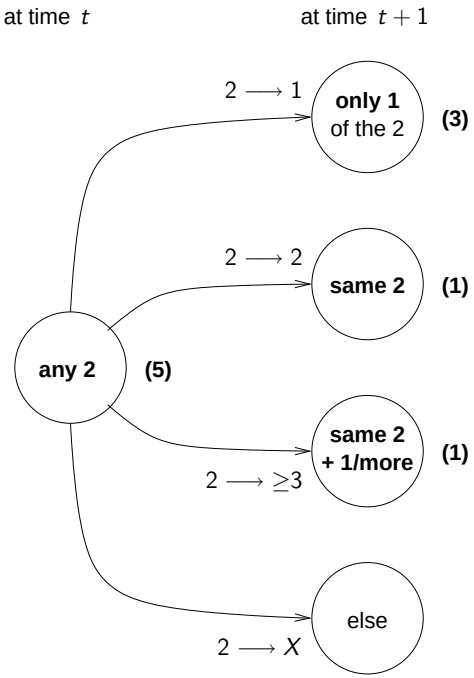

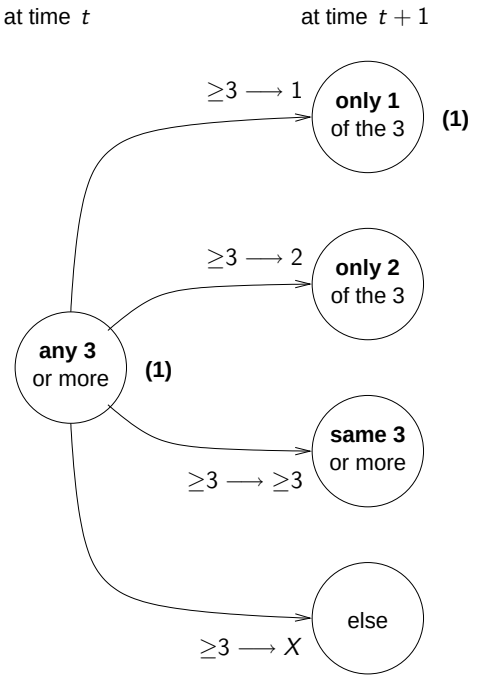

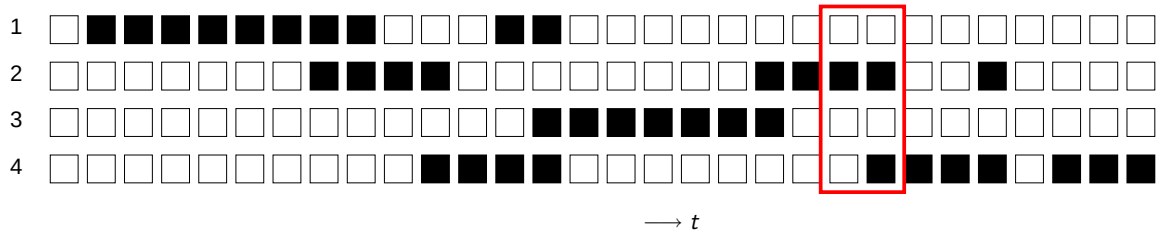

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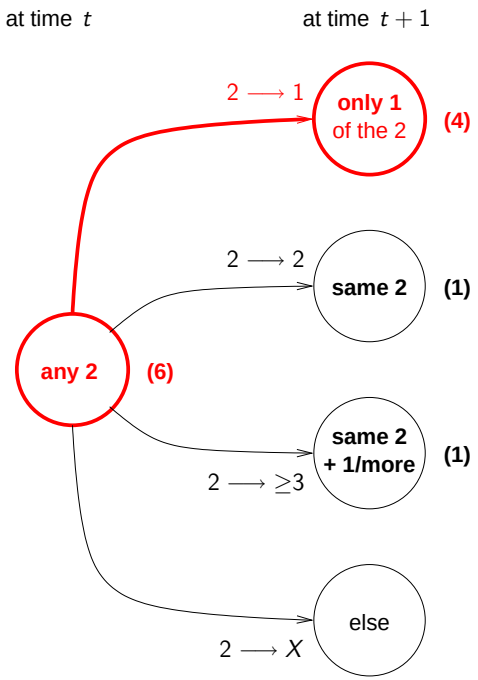

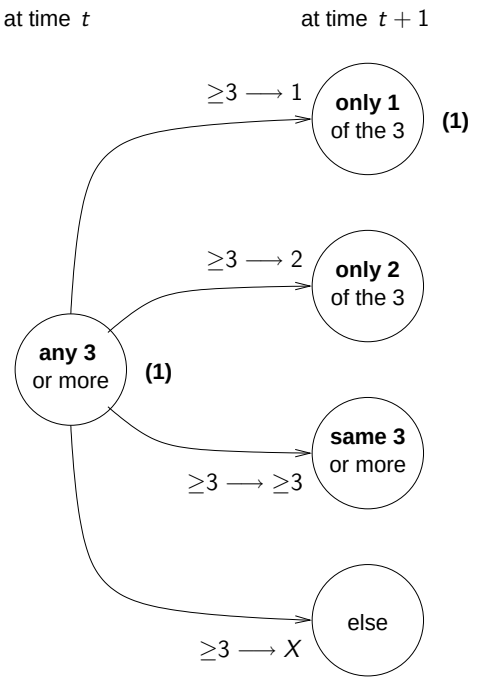

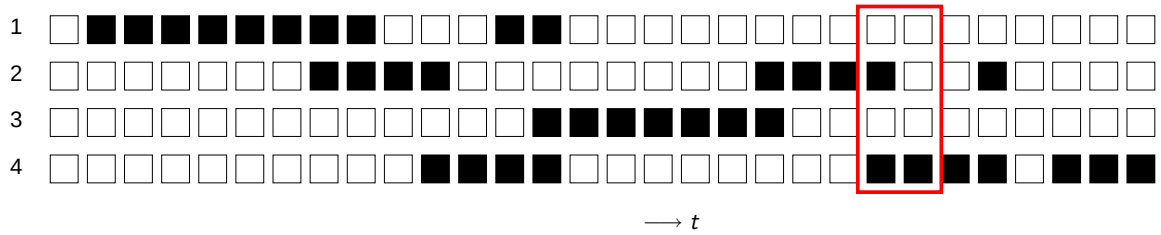

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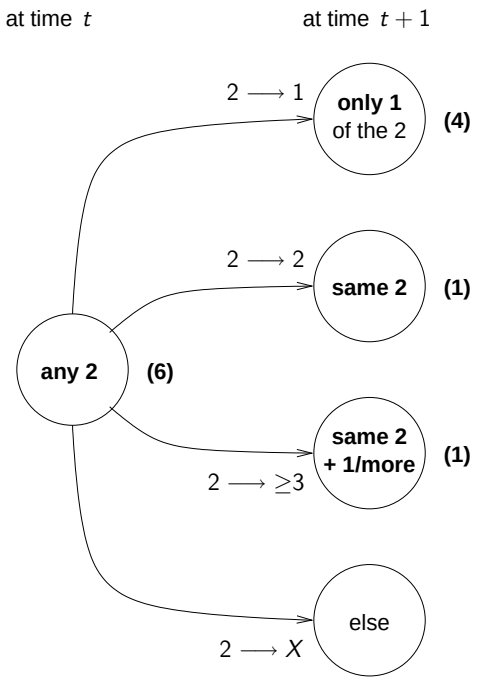

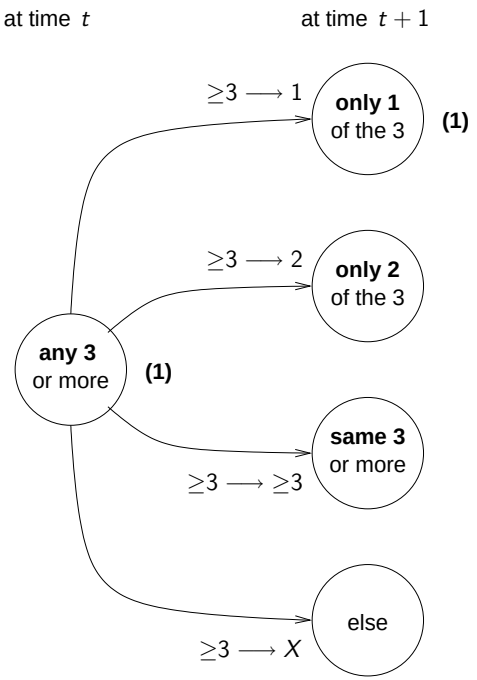

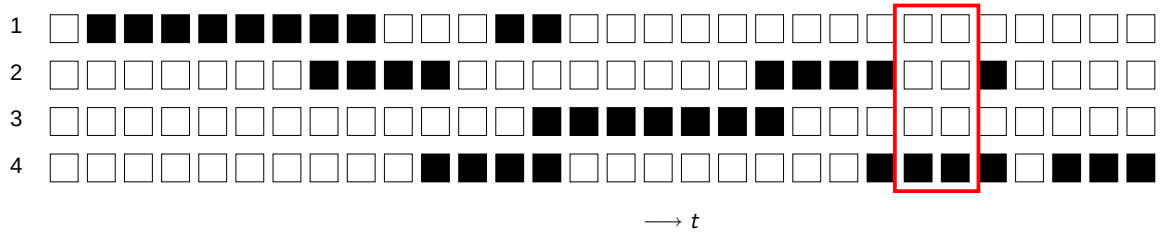

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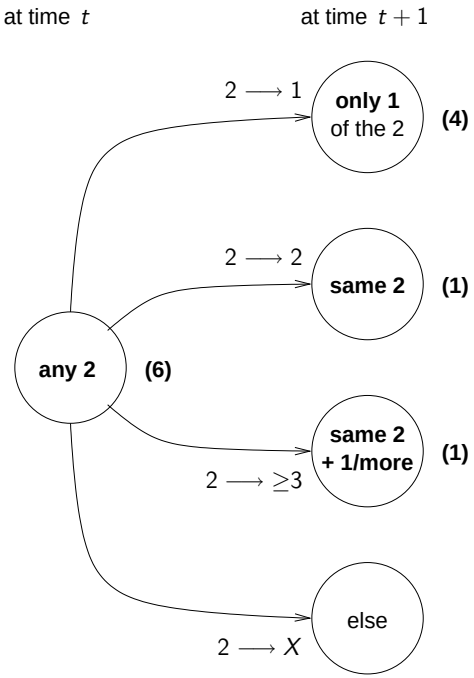

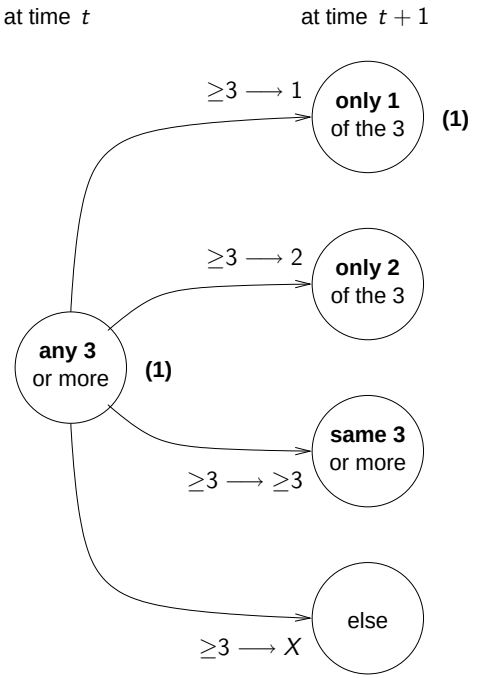

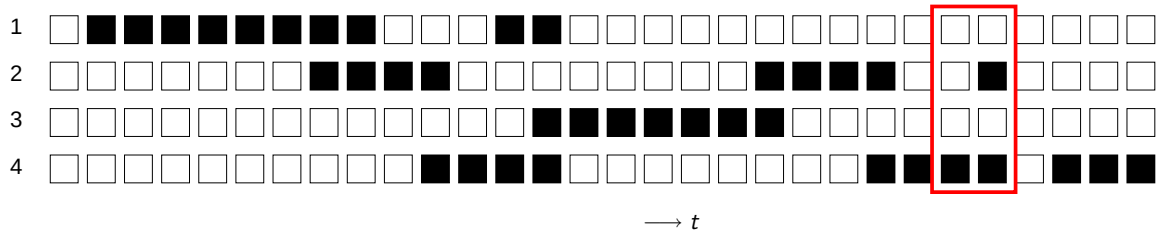

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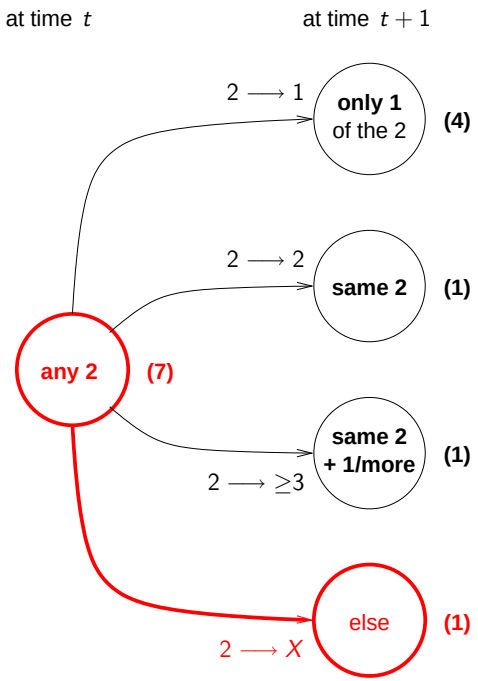

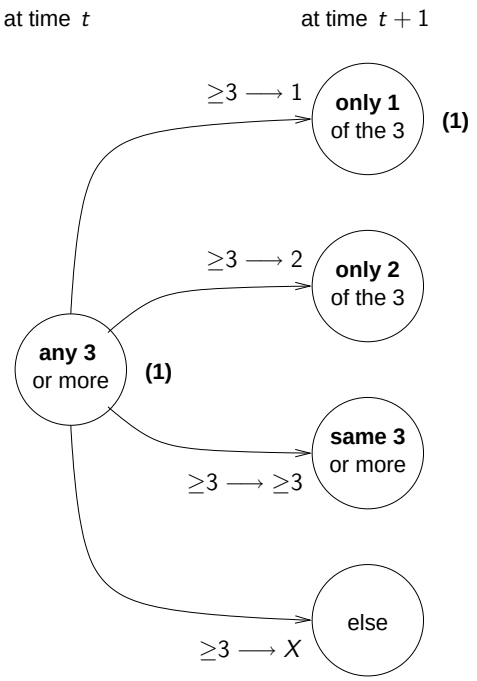

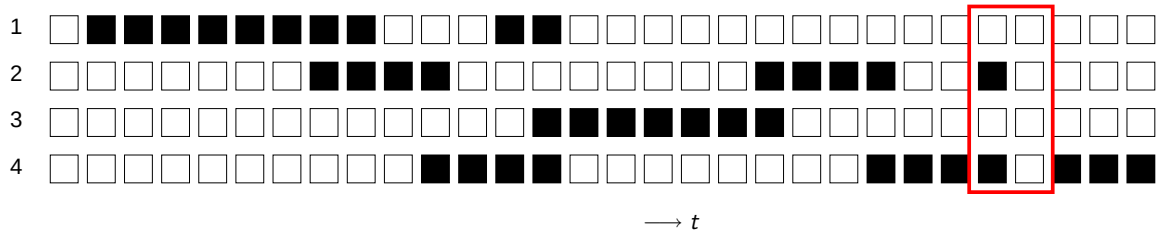

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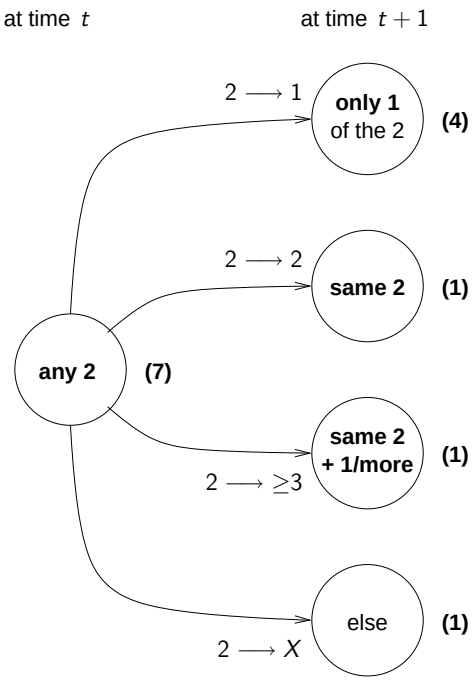

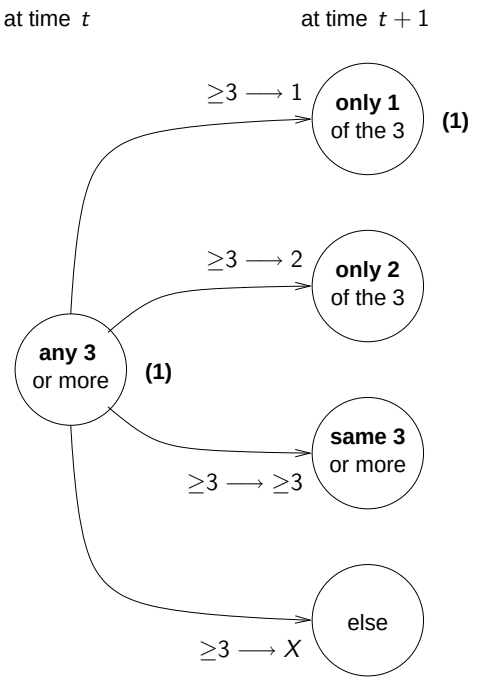

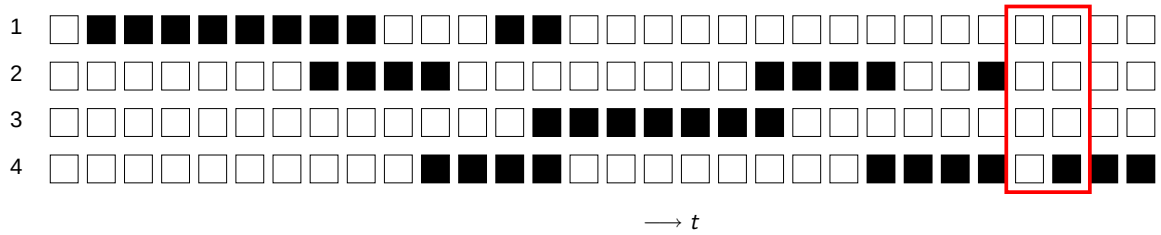

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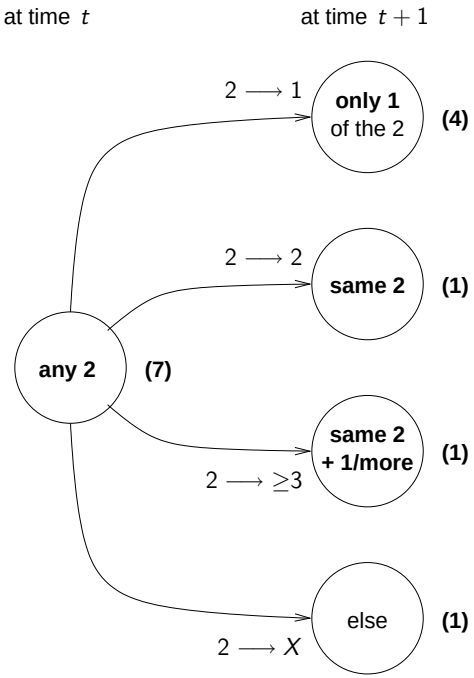

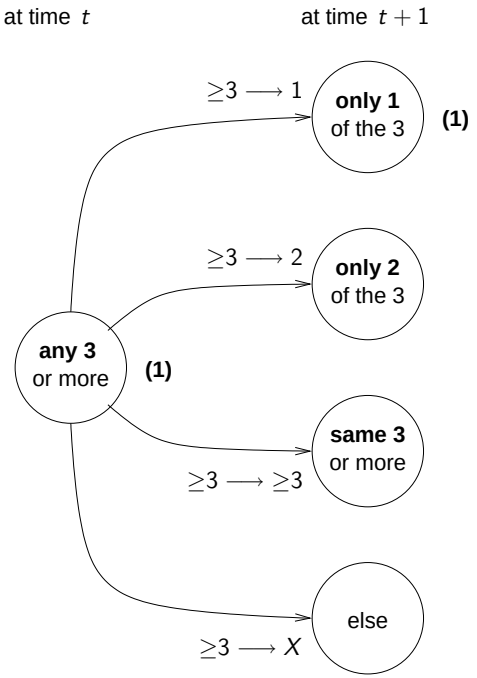

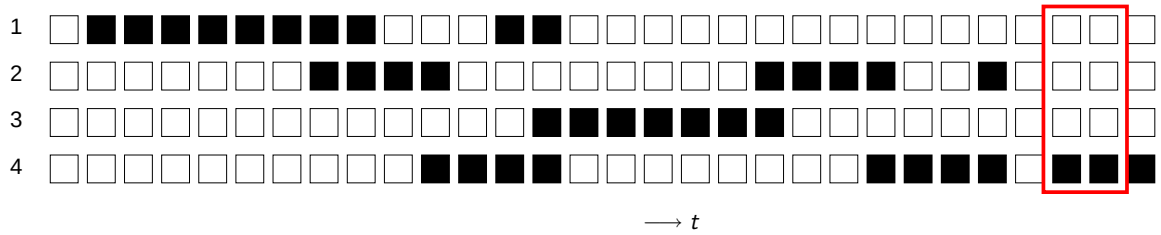

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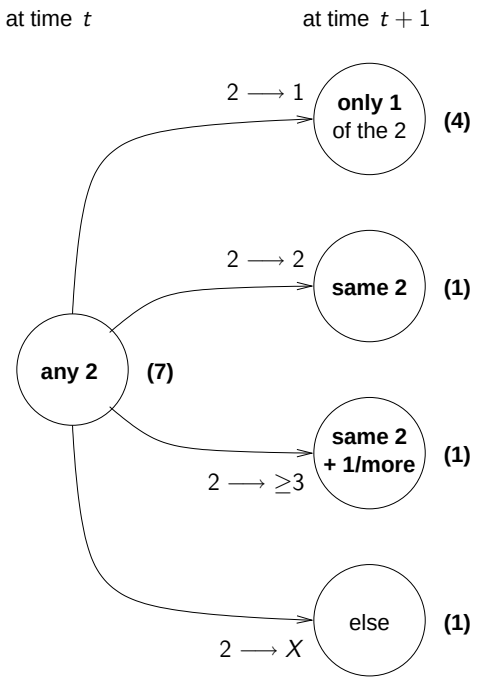

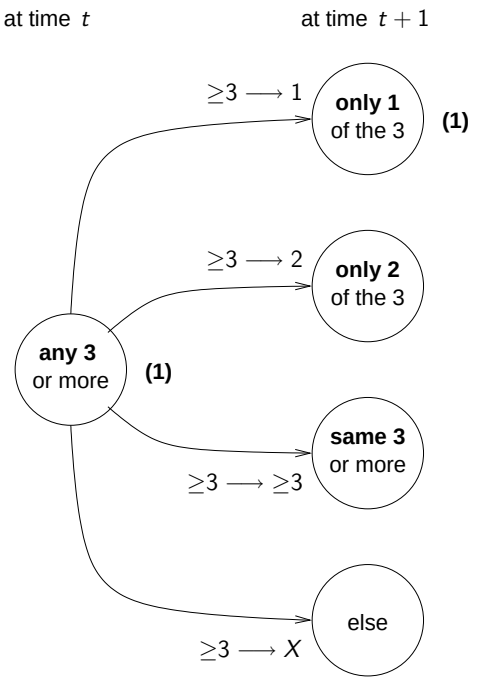

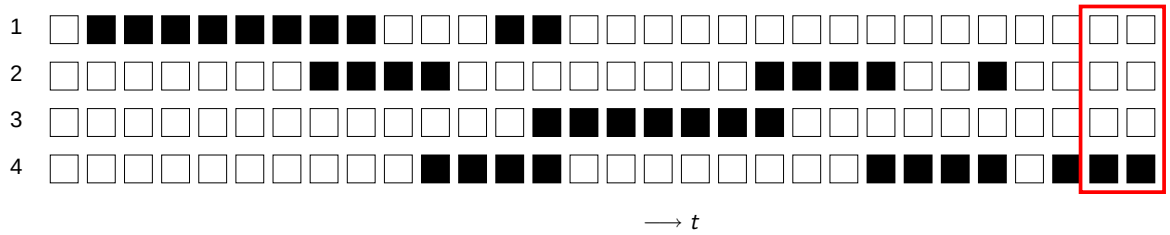

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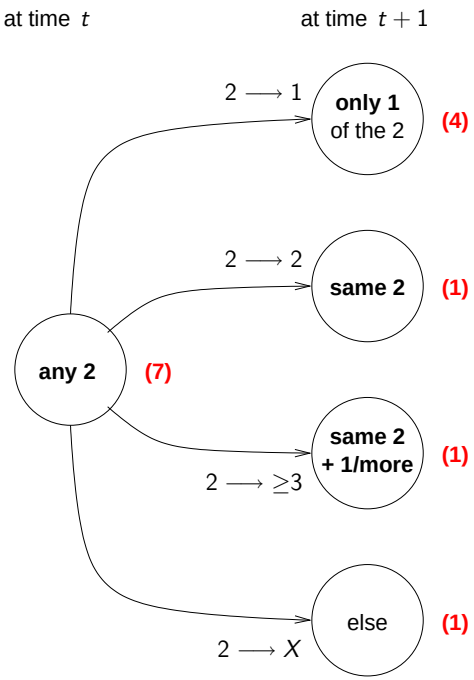

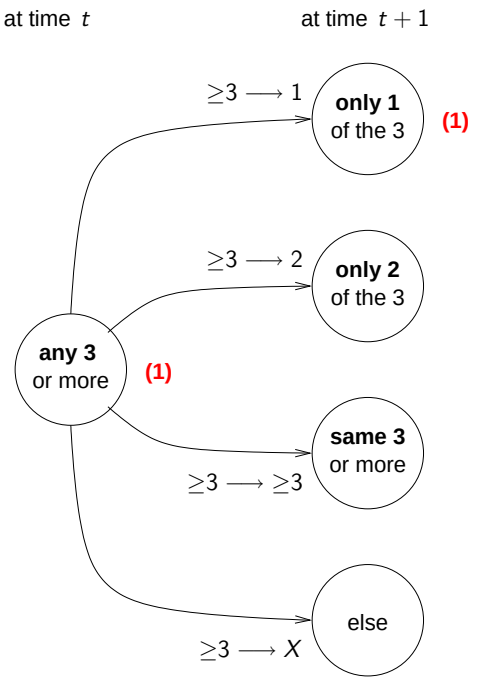

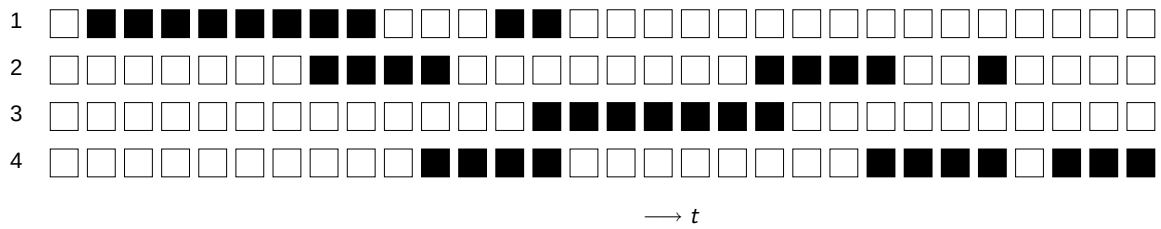

Overlap Dynamics: Results

Select Transition			CHIL06_1		CHIL06_2		
			rt07s_dev		rt07s_eval ::lectmtg		(all)
at t		at $t+1$	$\mathcal{S}$	$\mathcal{L}$	$\mathcal{S}$	$\mathcal{L}$	$\mathcal{L}$
2	$\rightarrow$	1	48.01	22.12	47.17	22.78	25.31
2	$\rightarrow$	2	37.95	60.18	40.11	60.44	55.34
2	$\rightarrow$	≥ 3	3.25	10.62	2.73	9.81	9.79
≥ 3	$\rightarrow$	1	17.35	5.08	18.49	7.69	5.63
≥ 3	$\rightarrow$	2	35.71	25.42	43.70	22.38	21.65
≥ 3	$\rightarrow$	≥ 3	36.73	69.49	29.41	69.23	69.91

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$T_{\mathcal{L}}/T_{\mathcal{V}}$	3.8%	10.2%	9.4%
$T_{\mathcal{L}_V}/T_{\mathcal{L}}$	88.2%	84.6%	74.3%
$T_{\mathcal{L}\cap\mathcal{S}}/T_{\mathcal{L}}$	49%	10.3%	4.9%
$ML(T_{bout})$	$\approx$ 0.8 seconds		1.1 s
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- occurrence of laughter in CHIL06 is similar to that in meetings, except:
  - in CHIL06_1, less laughter overall
  - higher proportion of voiced laughter
  - more "speech laughs"

Conclusions

- a **new** resource for acoustic modeling of laughter
  - 1576 bouts of laughter
  - 45.8 minutes of laughter
  - new domain
- occurrence of laughter in CHIL06 is similar to that in meetings, except:
  - in CHIL06_1, less laughter overall
  - higher proportion of voiced laughter
  - more "speech laughs"
  - $\longrightarrow$ **consequences for models on interaction when applied to laughter detection this domain**

The End

- **Thank you for attending.**
- We would also like to our annotators:
  - Matthew Bell
  - Brian Anna
  - Joseph Fridy
  - Brett Nelson