Introduction to Petri Nets

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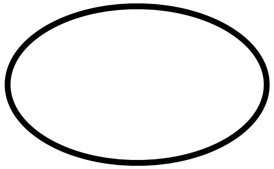
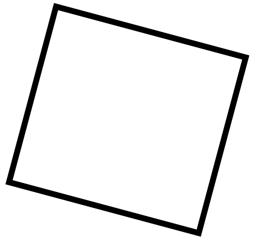
Welcome Guys :D

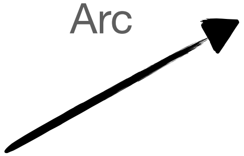
- Part 1: Intuitive Understanding of Petri nets
- Part 2: Basic Concepts
- Part 3: Elementary system nets
- Part 4: Sth interesting if we have time

Part 1: Intuitive Understanding



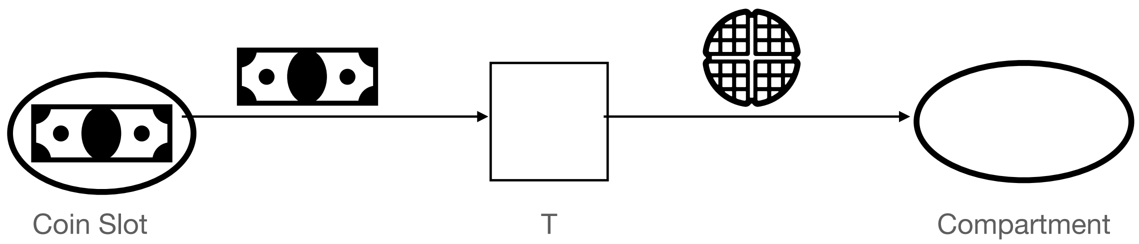


4 Components



Token

Part 1: Intuitive Understanding



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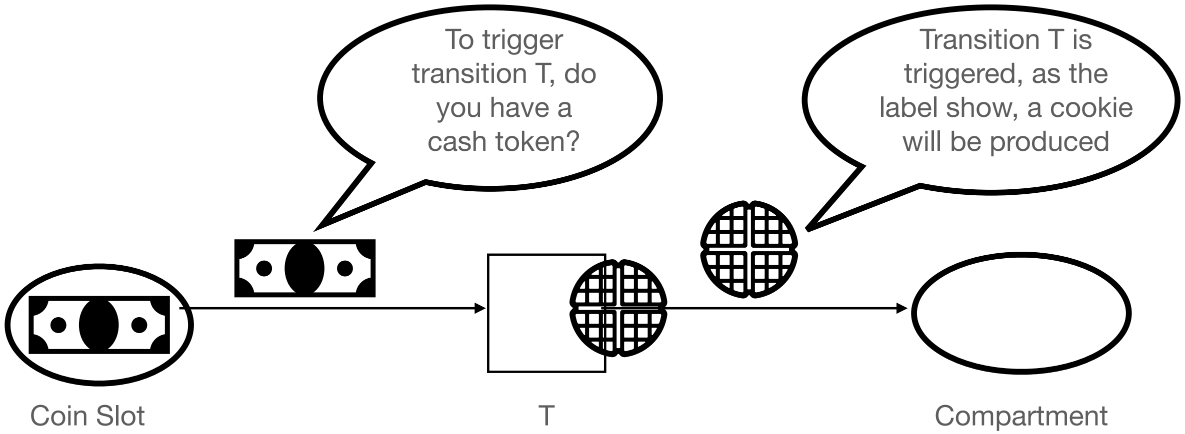
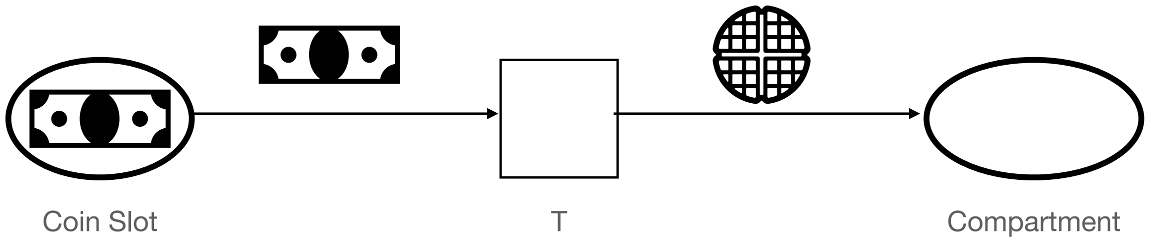
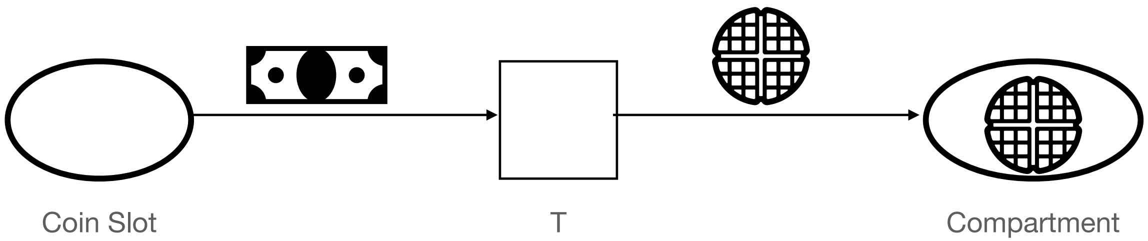


Part 1: Intuitive Understanding

Marking = State





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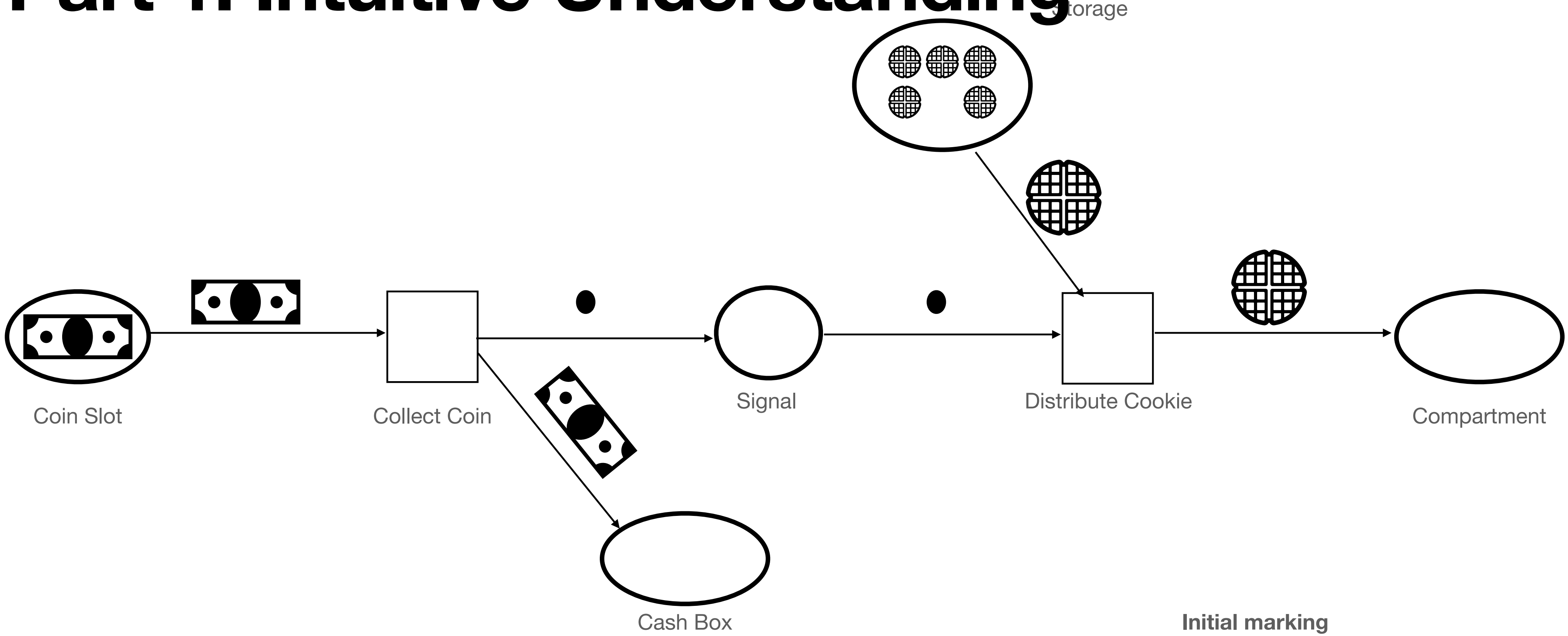

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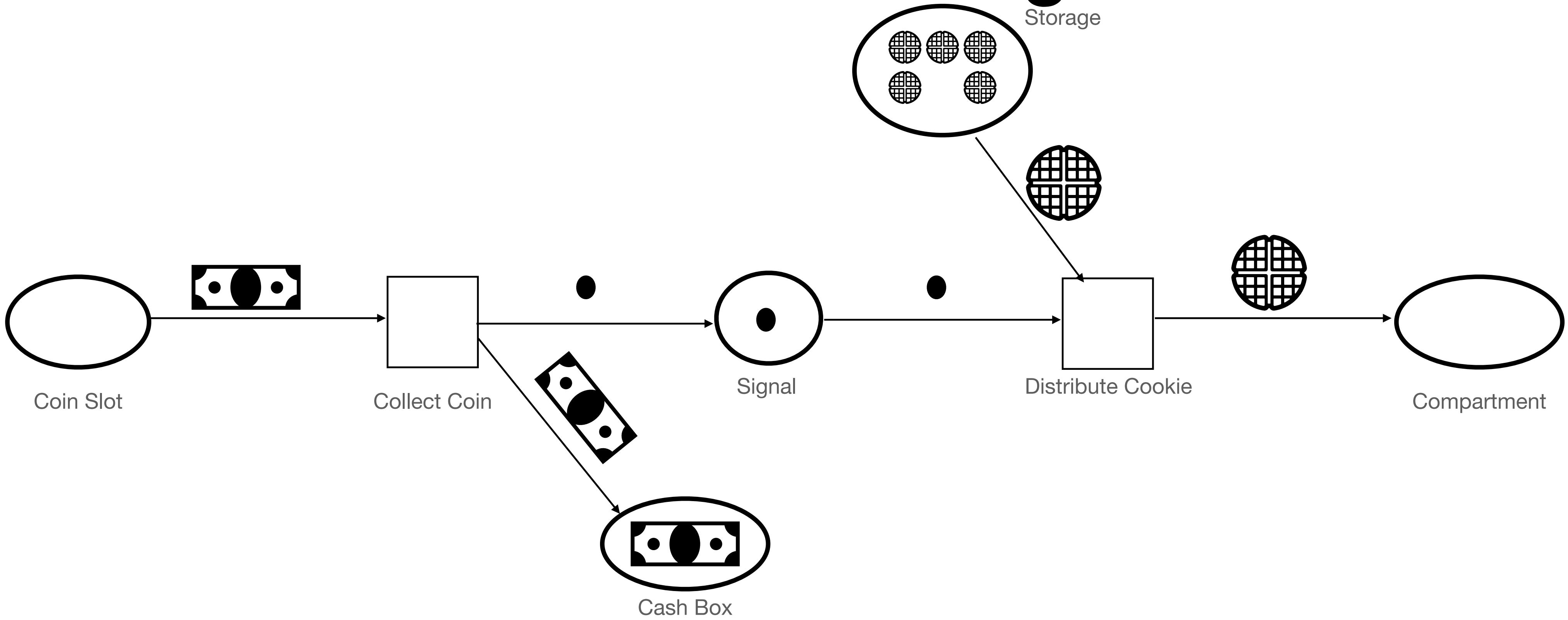

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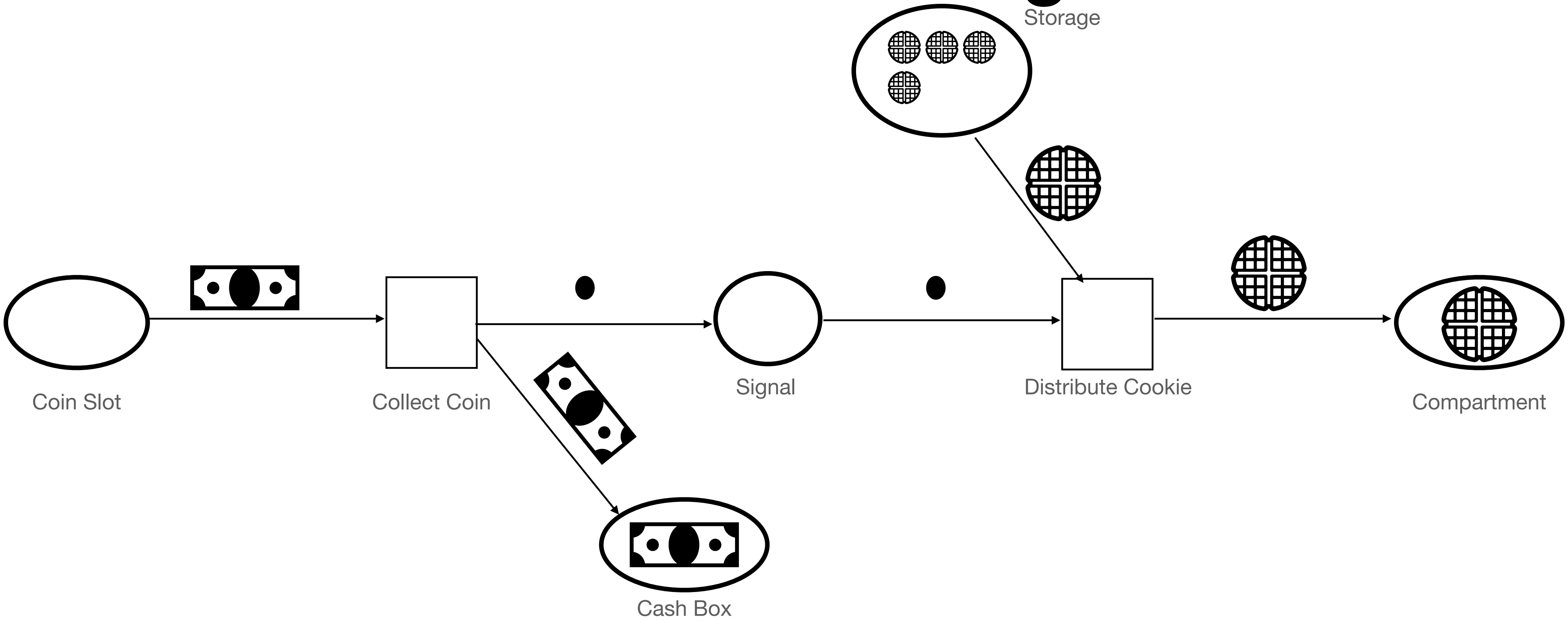
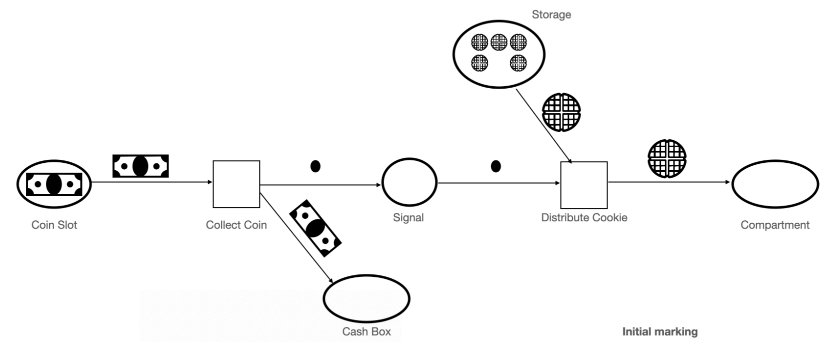
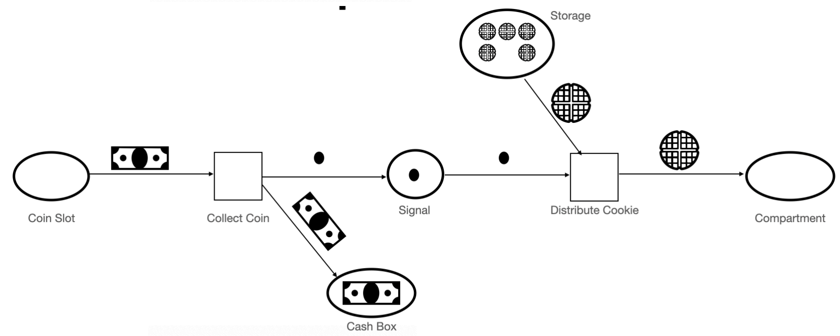
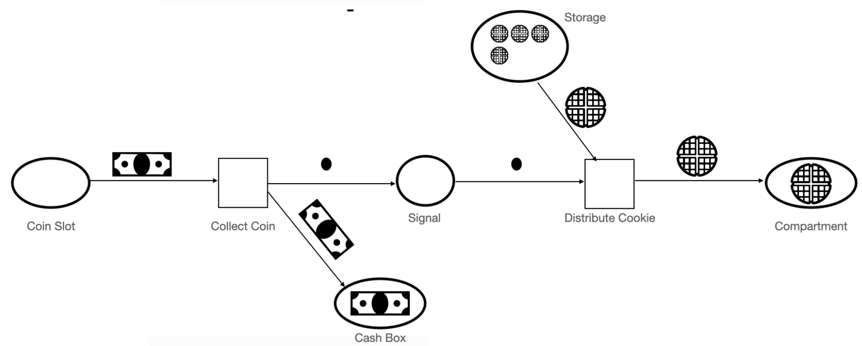


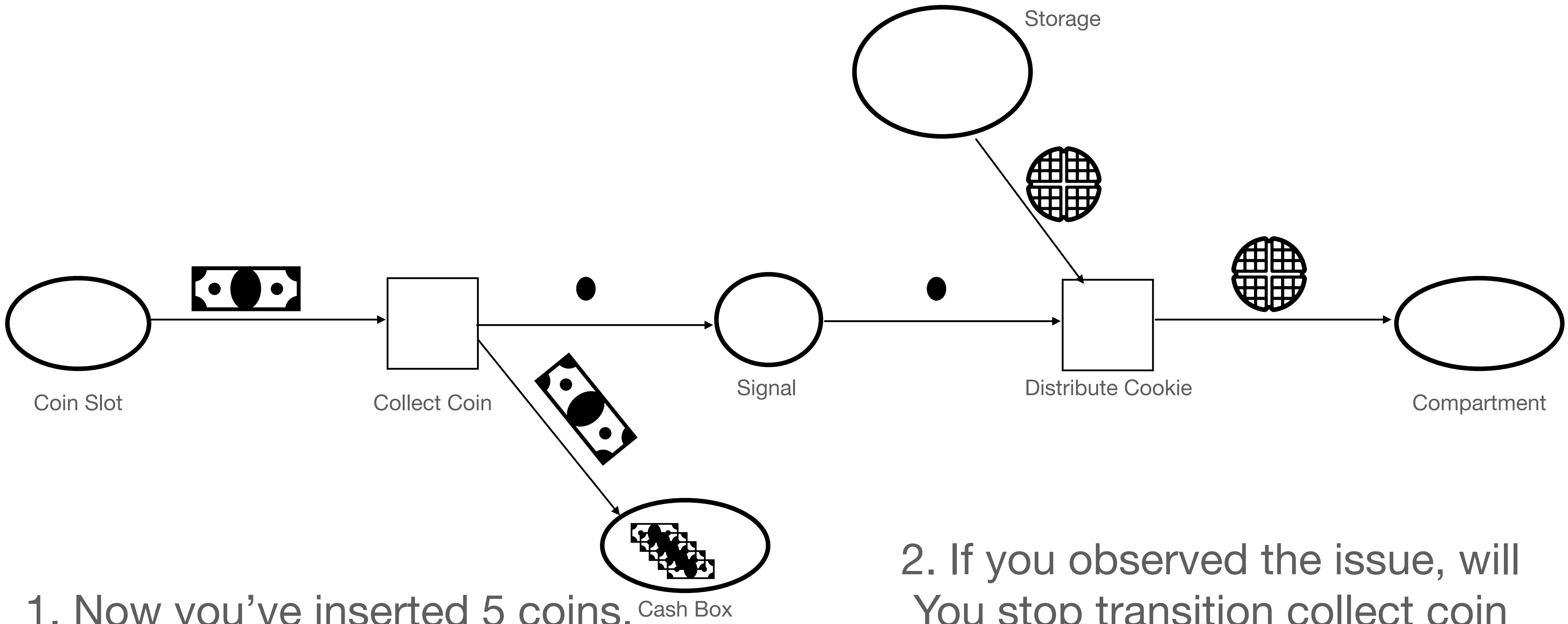
Part 1: Intuitive Understanding







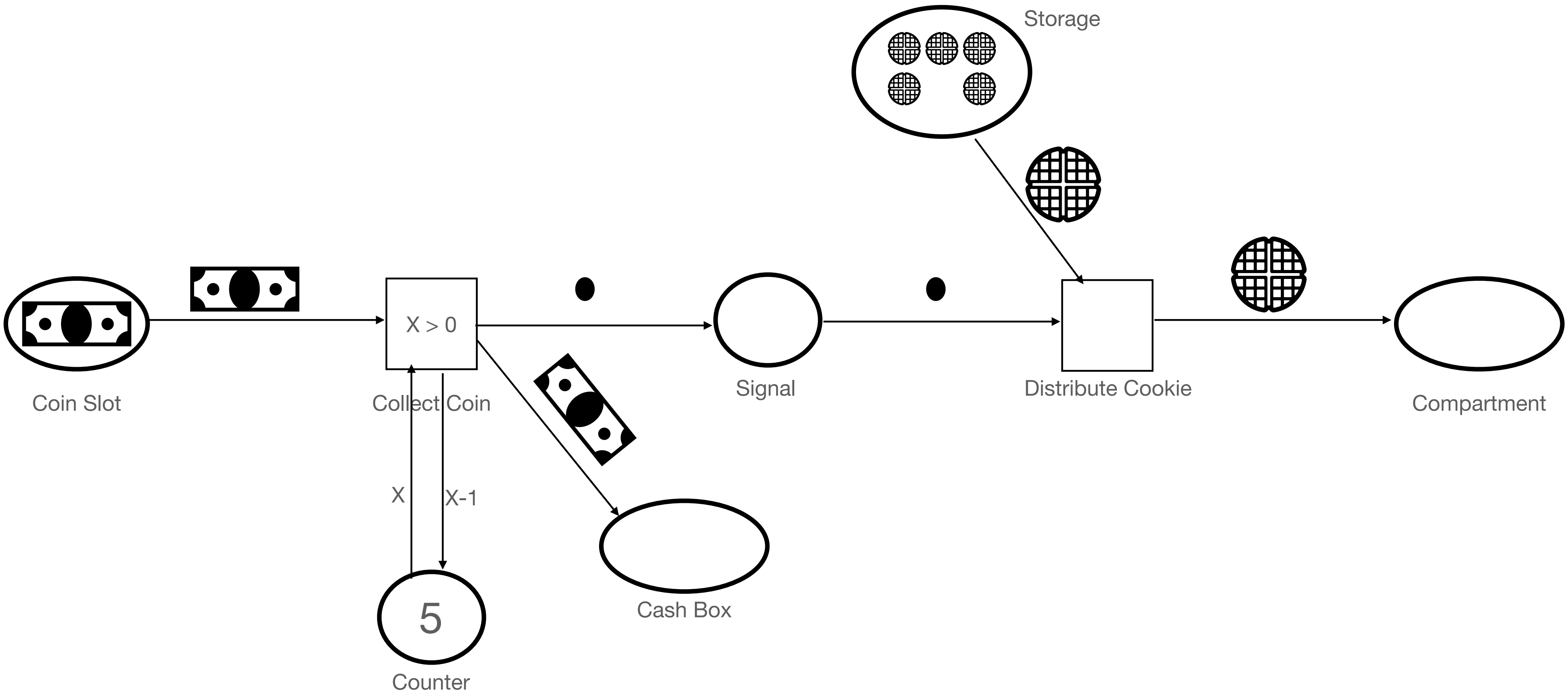
QUESTION TIME



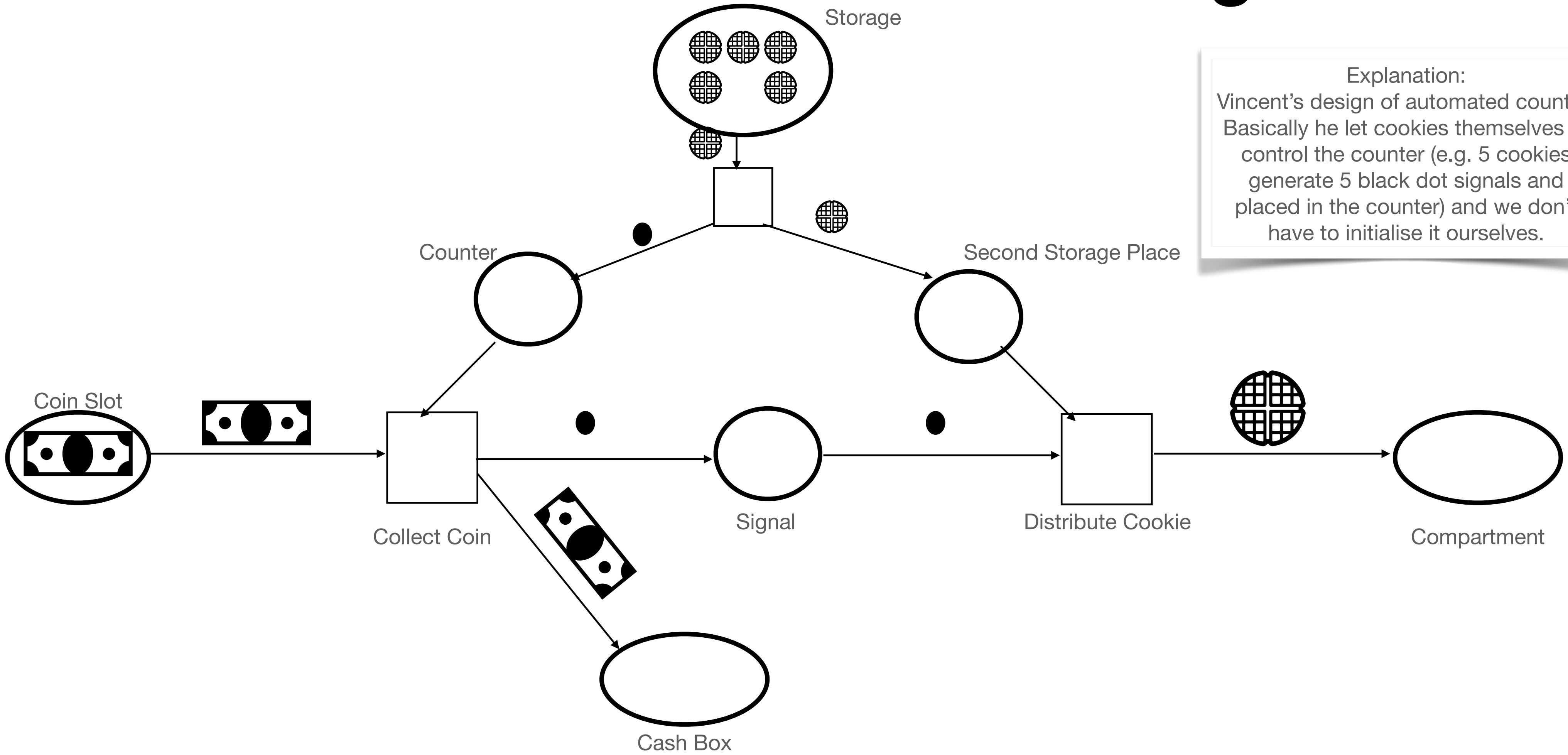
1. Now you've inserted 5 coins, will you insert a 6th coin?

2. If you observed the issue, will You stop transition collect coin or the transition distribute cookie?

QUESTION TIME

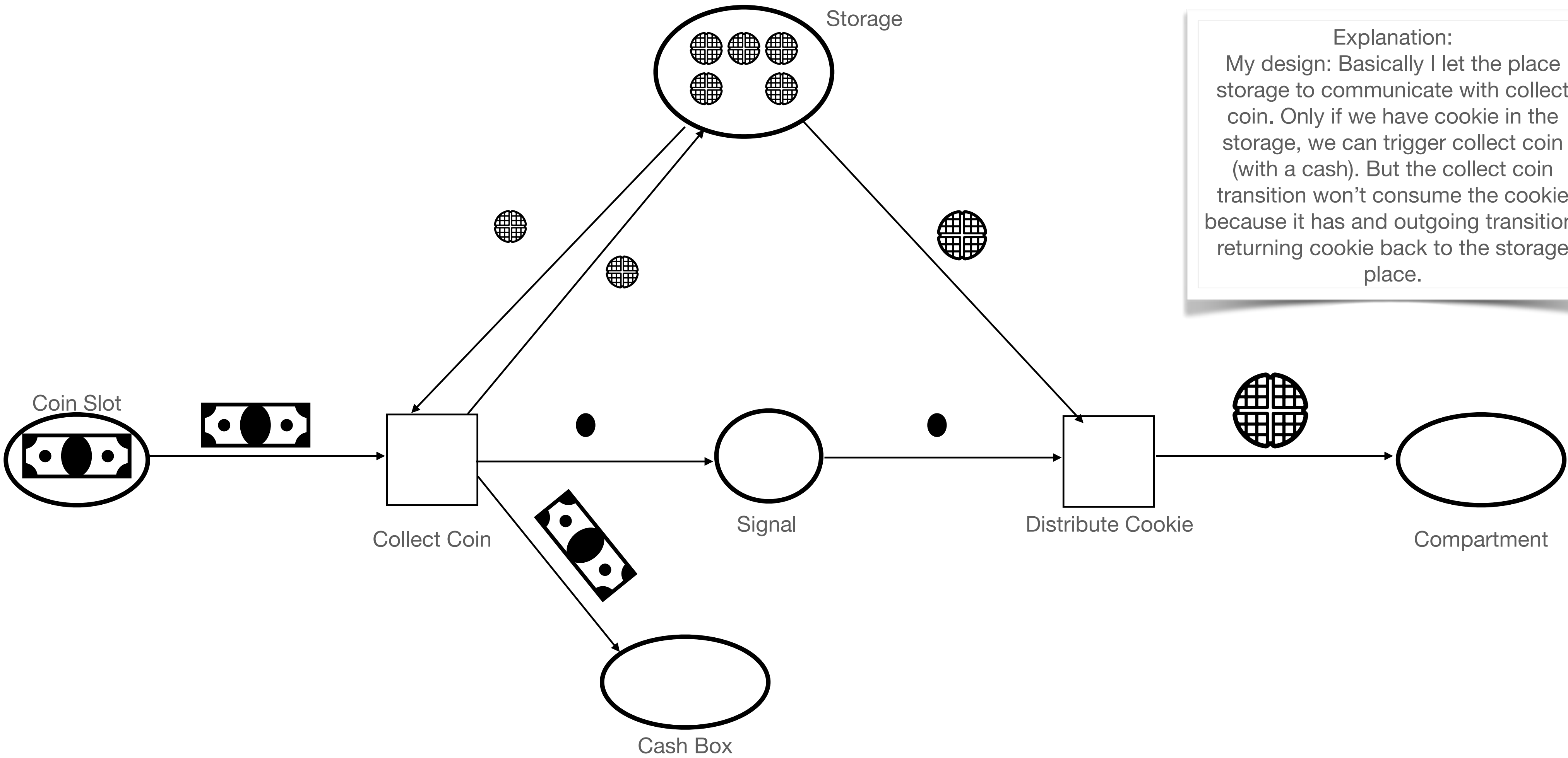


Vincent’s Automated Counter Design



Explanation:
Vincent’s design of automated counter: Basically he let cookies themselves to control the counter (e.g. 5 cookies generate 5 black dot signals and placed in the counter) and we don’t have to initialise it ourselves.

My Alternative design to this issue (without counter)



Explanation:
My design: Basically I let the place storage to communicate with collect coin. Only if we have cookie in the storage, we can trigger collect coin (with a cash). But the collect coin transition won't consume the cookie because it has and outgoing transition, returning cookie back to the storage place.

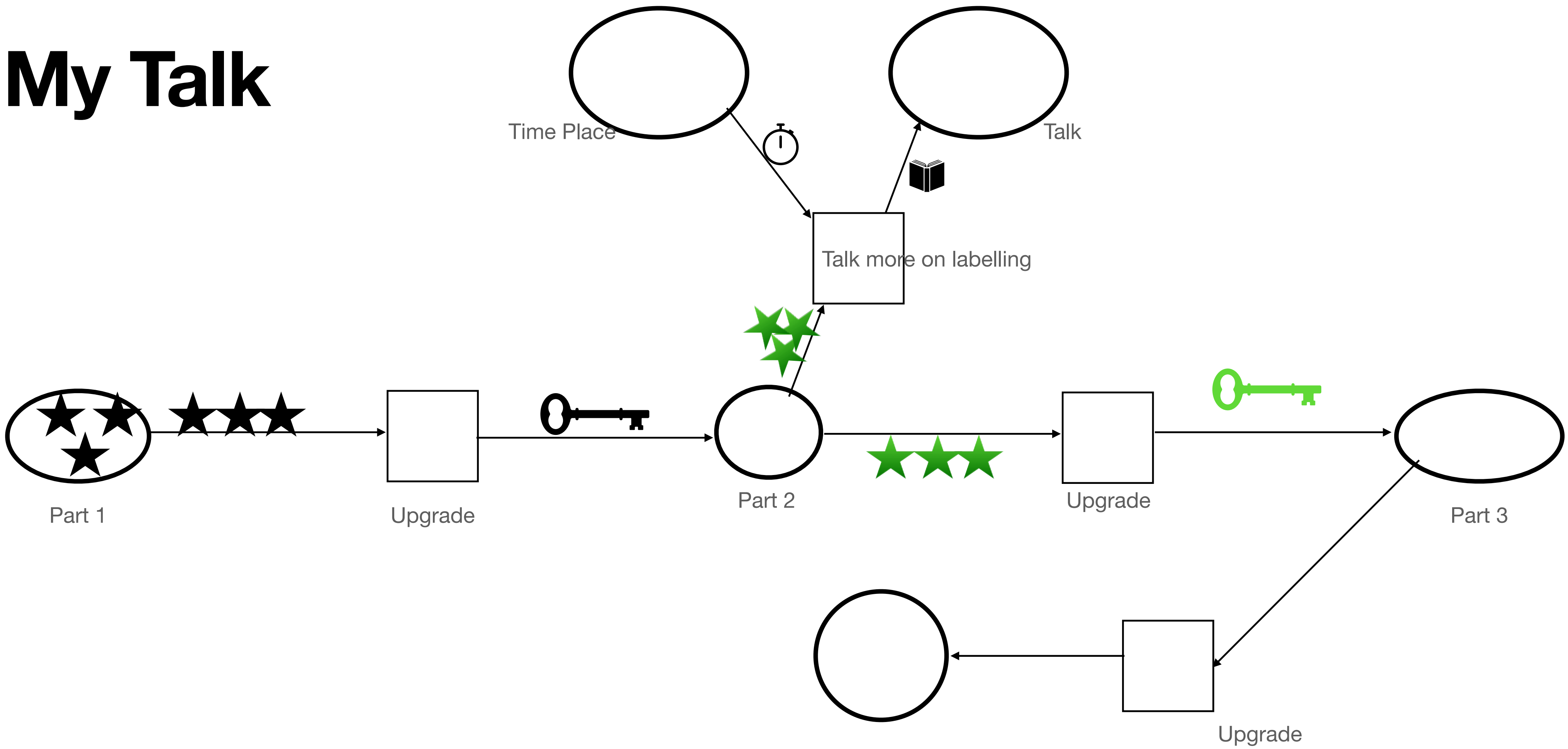
Part 1 Take Away

Intuitive understanding
of the 4
components

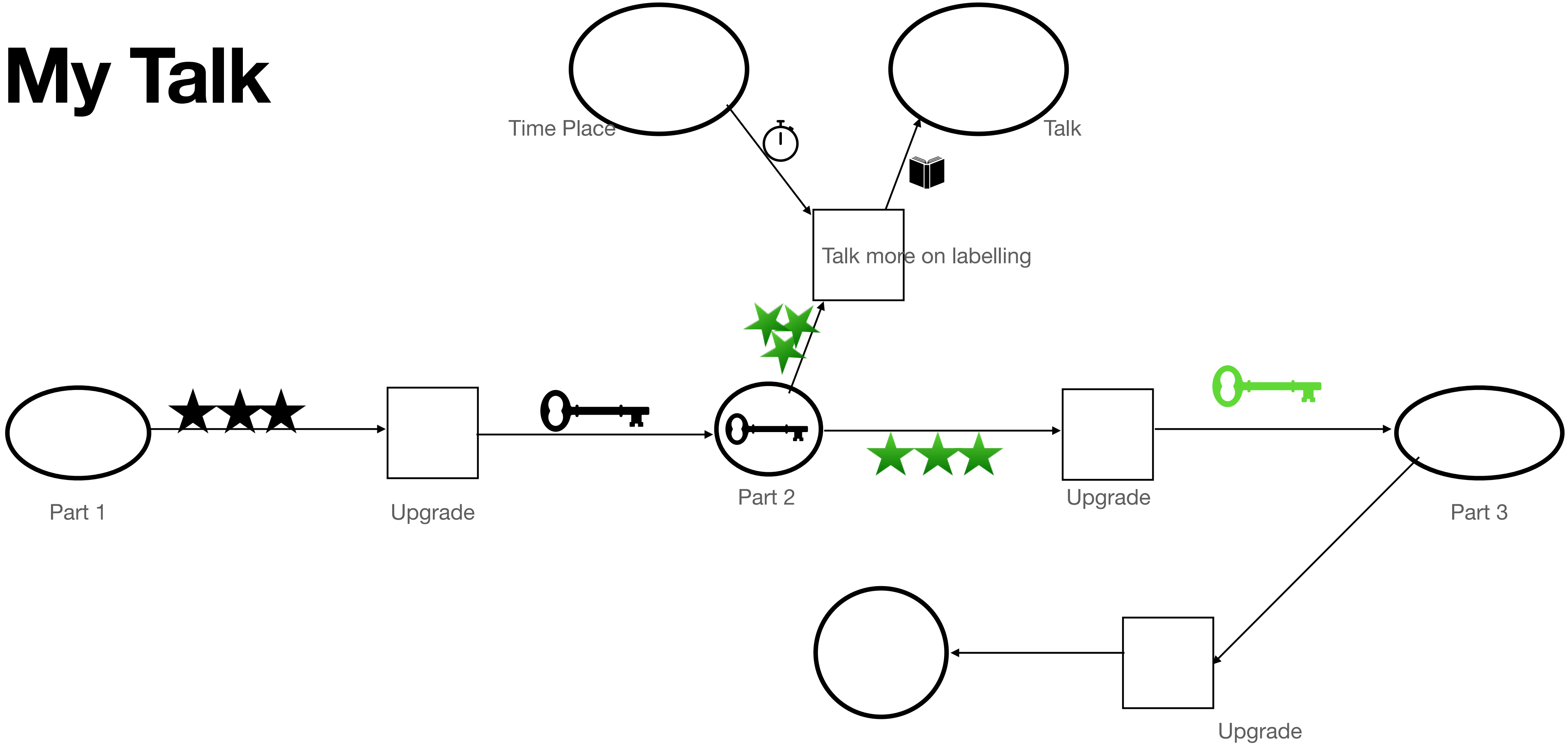
Distinction between
Enabling of transition
And
Occurrence of it

Petri Nets modeling
Technique is
VERY
flexible and expressive

My Talk


Time Place
Talk
Talk more on labelling
Part 1
Upgrade
Part 2
Upgrade
Part 3
Upgrade

My Talk


Time Place
Talk
Talk more on labelling
Part 1
Upgrade
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Upgrade

Part 2: Basic Concepts

How is a place different from a transition?

What is a place?

Can an arc point from a transition to another transition?

Can an arc point from a place to another place?

How do you know if you model sth correctly?

Do you always have to draw a lot to model sth?

How is petri nets different from other modelling technique?

Part 2: Basic Concepts

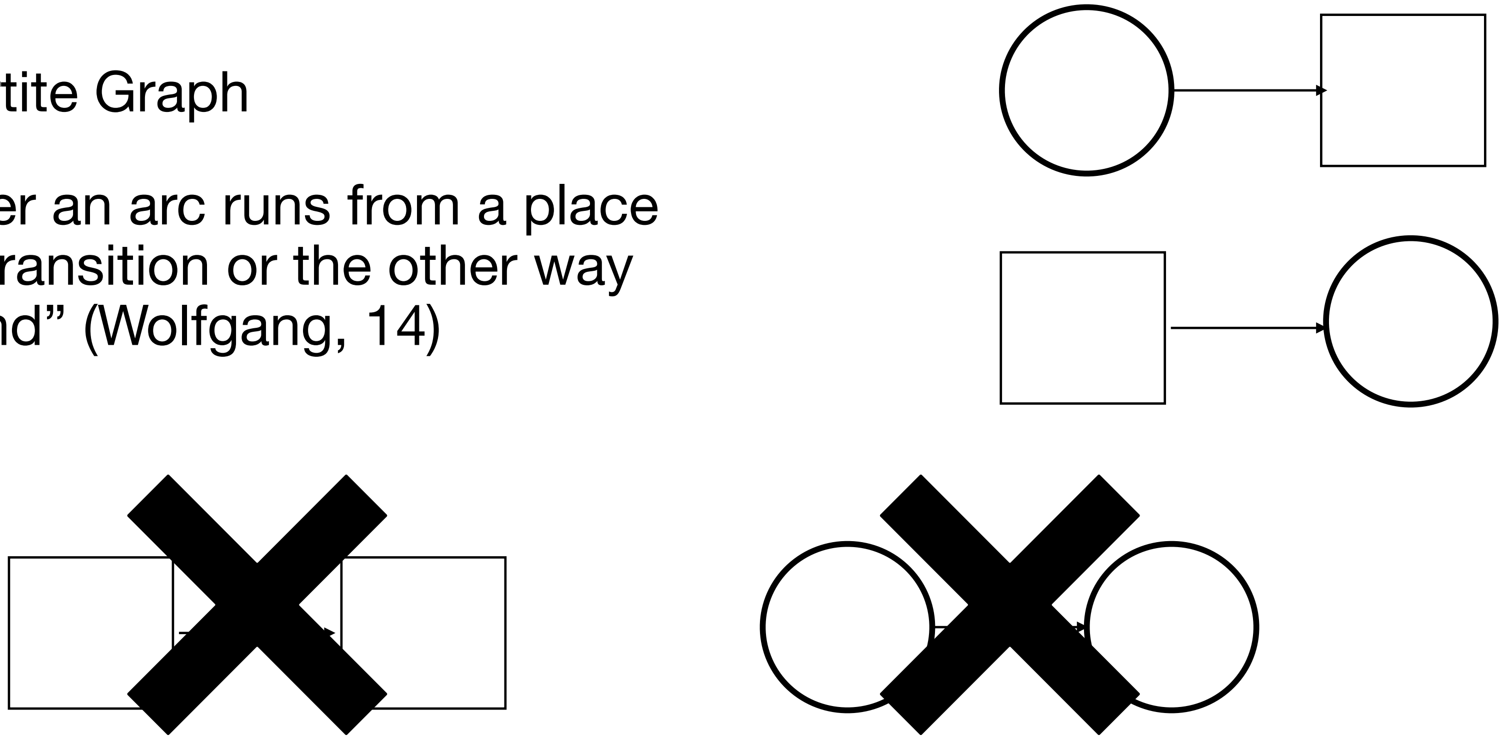
- **Place**: passive component
  - Store
  - Accumulate
  - Show

Not A STATE

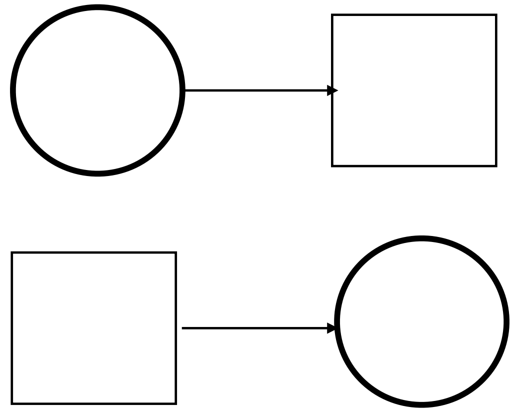
- **Transition**: active component
  - Consume
  - Transport
  - Produce
  - Change

Part 2: Basic Concepts

- Arc
    - Bipartite Graph
    - “Either an arc runs from a place to a transition or the other way around” (Wolfgang, 14)

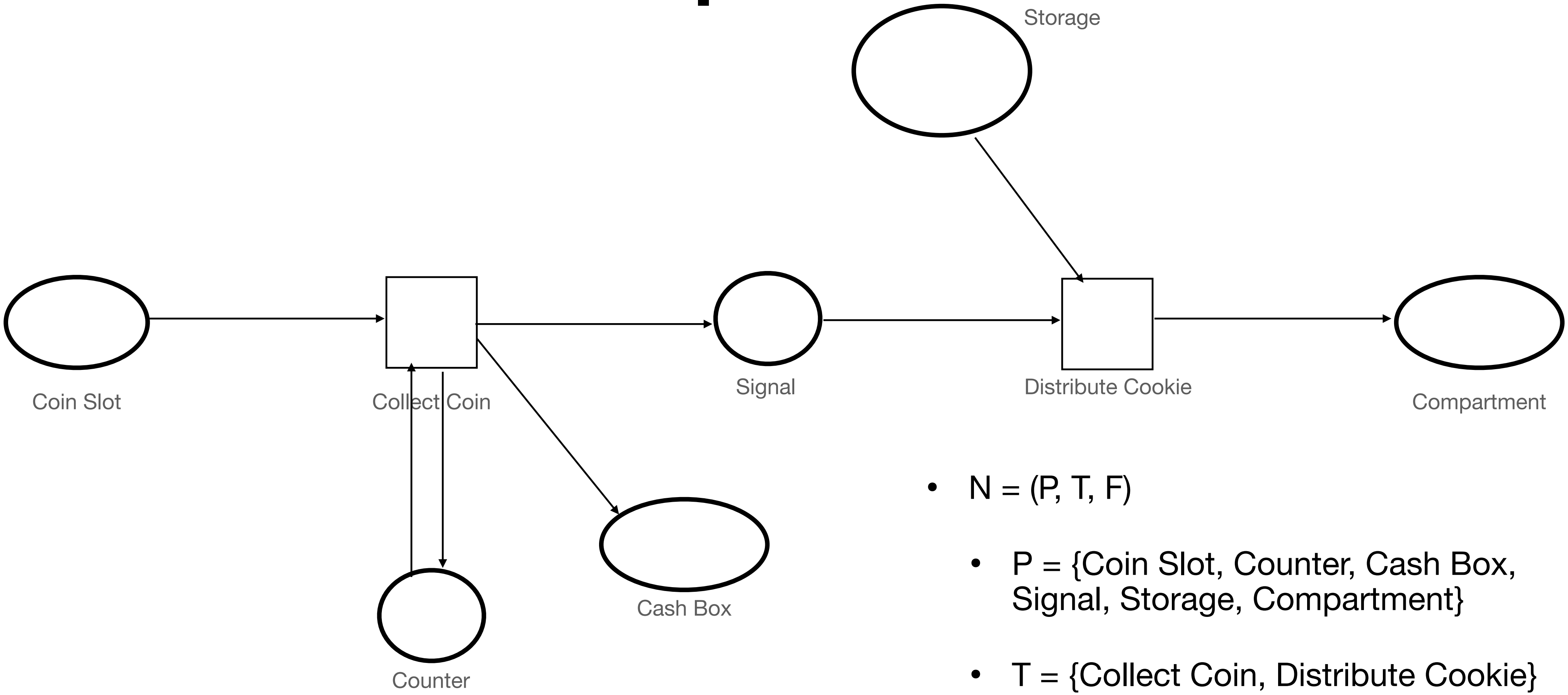


Part 2: Basic Concepts



- Net Structure
  - N = (P, T, F)
    - P: set of all places
    - T: set of all transitions
    - $F \subseteq (P \times T) \cup (T \times P)$

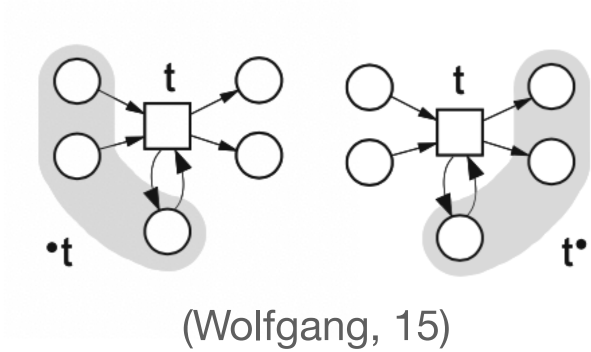
Part 2: Basic Concepts



- N = (P, T, F)
  - P = {Coin Slot, Counter, Cash Box, Signal, Storage, Compartment}
  - T = {Collect Coin, Distribute Cookie}
  - F ⊆ (P x T) U (T x P

Part 2: Basic Concepts

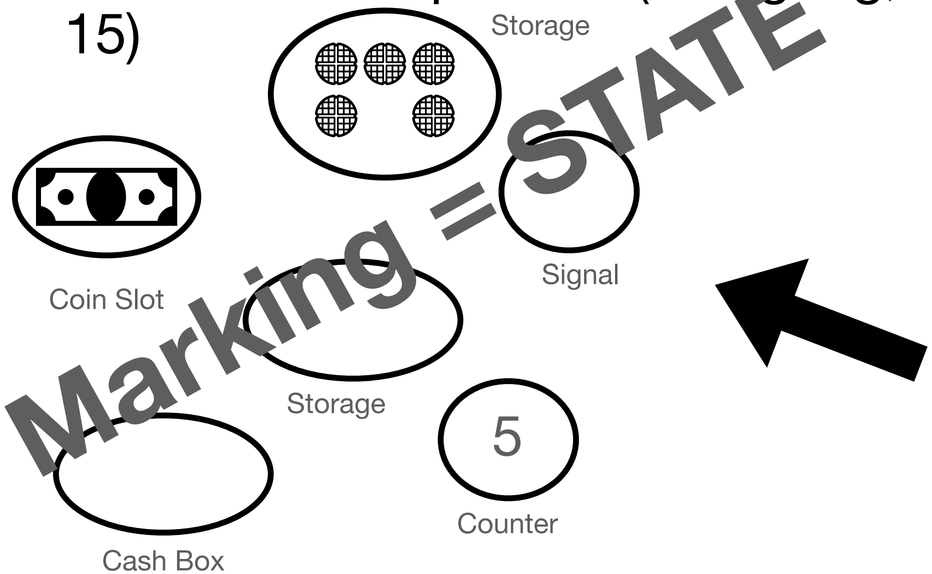
- Pre-set and Post-set
  - In an unambiguously defined Net structure N, for a component x (place/transition) we can define
    - Pre-set of x: ${}^\bullet x =_{\mathrm{def}} \{y \mid yFx\}$
    - Post-set of x: $x^\bullet =_{\mathrm{def}} \{y \mid xFy\}$.
    - Loop: $x \in {}^\bullet y$ and $y \in {}^\bullet x$



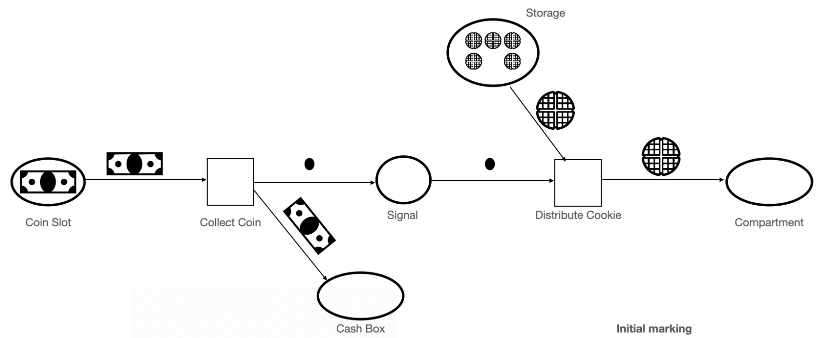
(Wolfgang, 15)

Part 2: Basic Concepts

- Marking
  - “A marking is a distribution of tokens across places.”(Wolfgang, 15)



- Note:
  - All places must be considered.
  - Marking can be represented graphically. But not necessarily.



Part 2: Basic Concepts

- Multiset
  - Example: mixed kinds of tokens in a place.
    - [🧇🧇🧇🧇🧇]
  - A multiset a is formally a mapping
  - a : U —> N
- Domain: Universe
  - Sufficiently Large
  - Collection of all examined tokens
  - E.g {🧇 💵 🥚 0 1 2 3 4 5 }
- Codomain: Natural Number

Part 2: Basic Concepts

- Multiset Example:
    - U = {🧇 💵 🥚 0 1 2 3 4 5 }
    - R = [🧇 🧇 🧇 💵 💵 🥚]
        - a(💵) = 2
        - a(🧇) = 3
        - a(🥚) = 1
- a(u) = 0 for any other u in U
    - a(3) = 0
    - a(2) = 0

Part 2: Basic Concepts

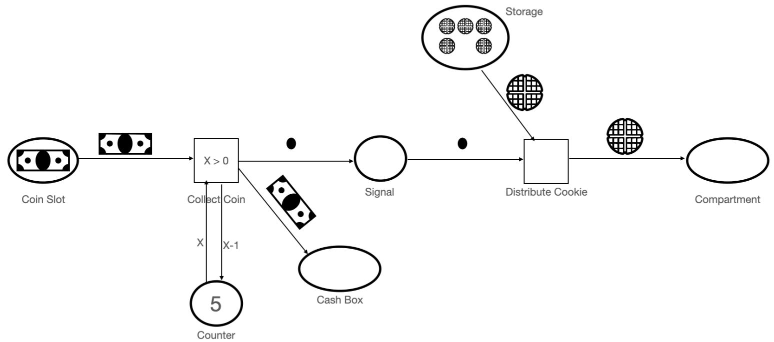
What about elementary system nets?
- What is U?
- What is M(U)?
- Assume we allow at most one black
- dot in one place,
- do we still need the data structure

multiset?

- $\mathcal{M}$(U): a set of all multisets over U
  - When U can be unambiguously identified, we write $\mathcal{M}$(U)
  - Otherwise, we just write $\mathcal{M}$.
- Example: U = {🌐💵}
- $\mathcal{M}$(U) = {[ ], [🌐], [💵], [🌐🌐], [🌐🌐💵]…}
- A multiset a is finite if
  - a(u) ≠ 0 for only finite number of u ∈ U.
  - +, -, ≥,≤,=

Part 2: Basic Concepts

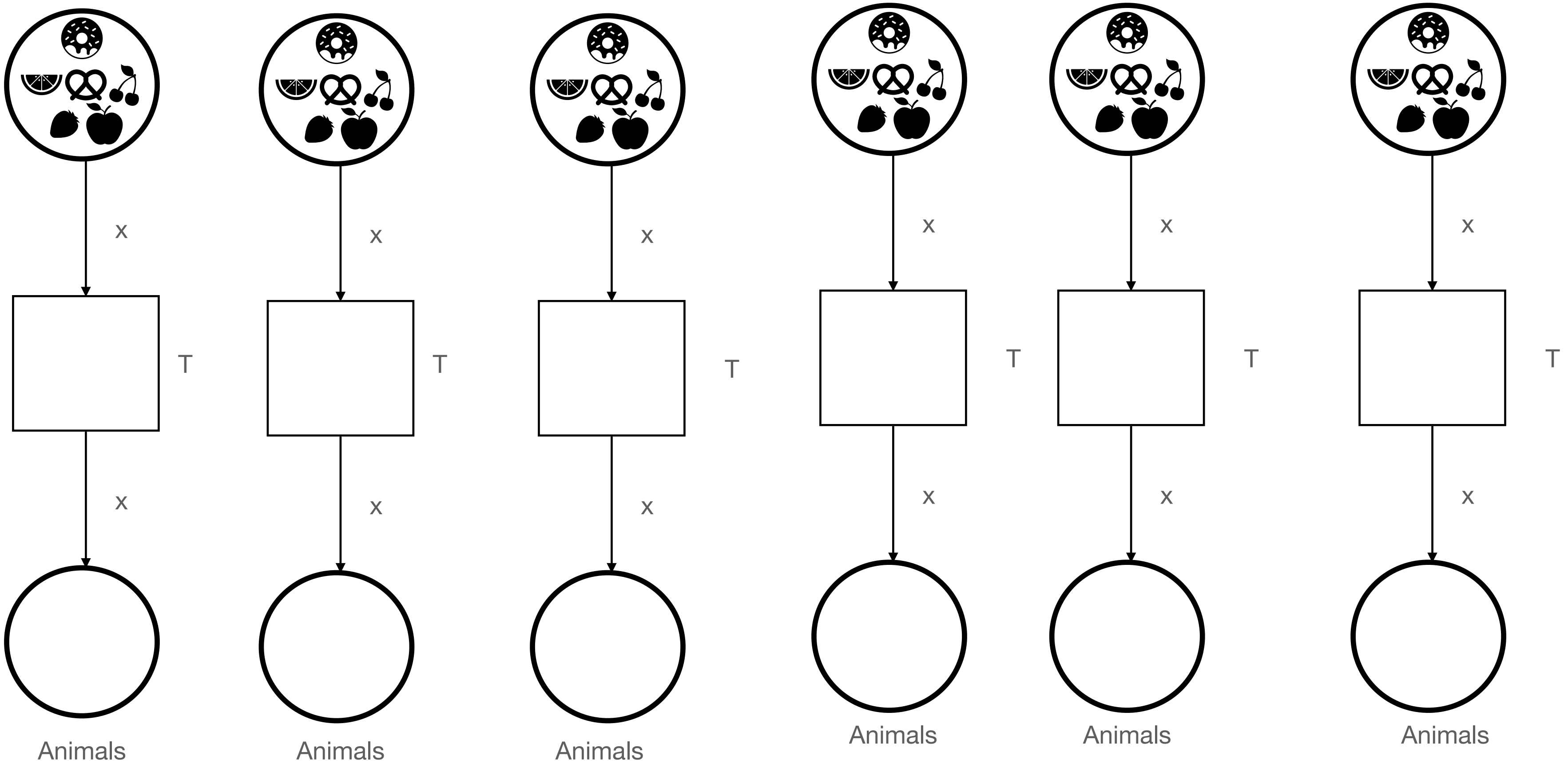
- Marking: with the help of multisets: M: P -> $\mathcal{M}$(U)
  - M_0(coin slot) = [ ]
    - a( ) = 1
  - M_0(cash box) = M_0(signal) = M_0(compartment)
    - a()=0
- M_0(storage) = [ ]
  - a( ) = 5
- M_0(counter) = [5]
  - a(5) = 1



Part 2: Basic Concepts

- System Net
  - Net structure + Initial Marking + Transition condition (labelling in transition) + Arc_labellings + cold_transition
- Reachability of Marking: reachability is not so different from reachability of states in process graph especially in part 3.
- Final Marking

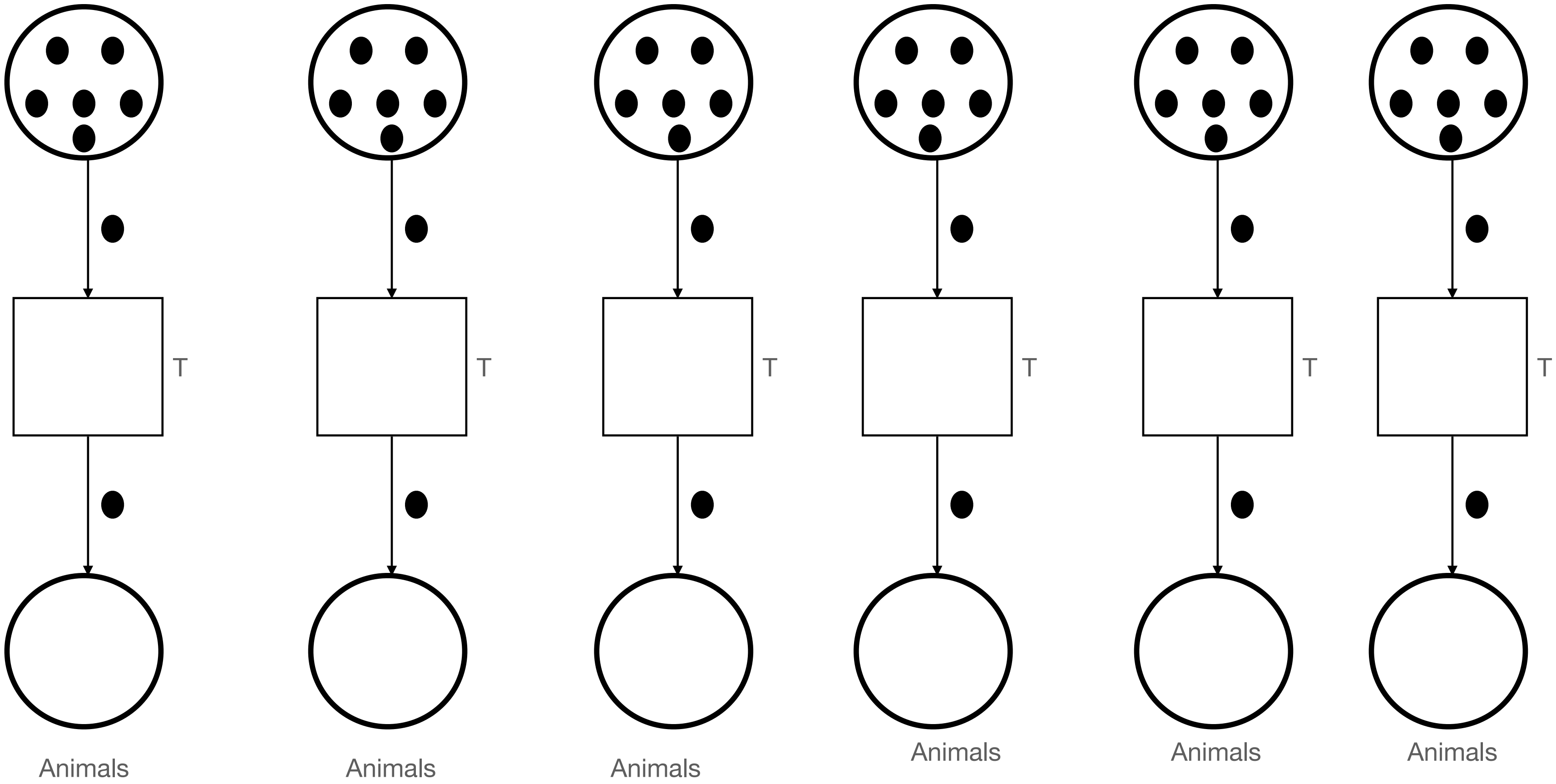
QUESTION TIME



How many markings are there from the initial marking?

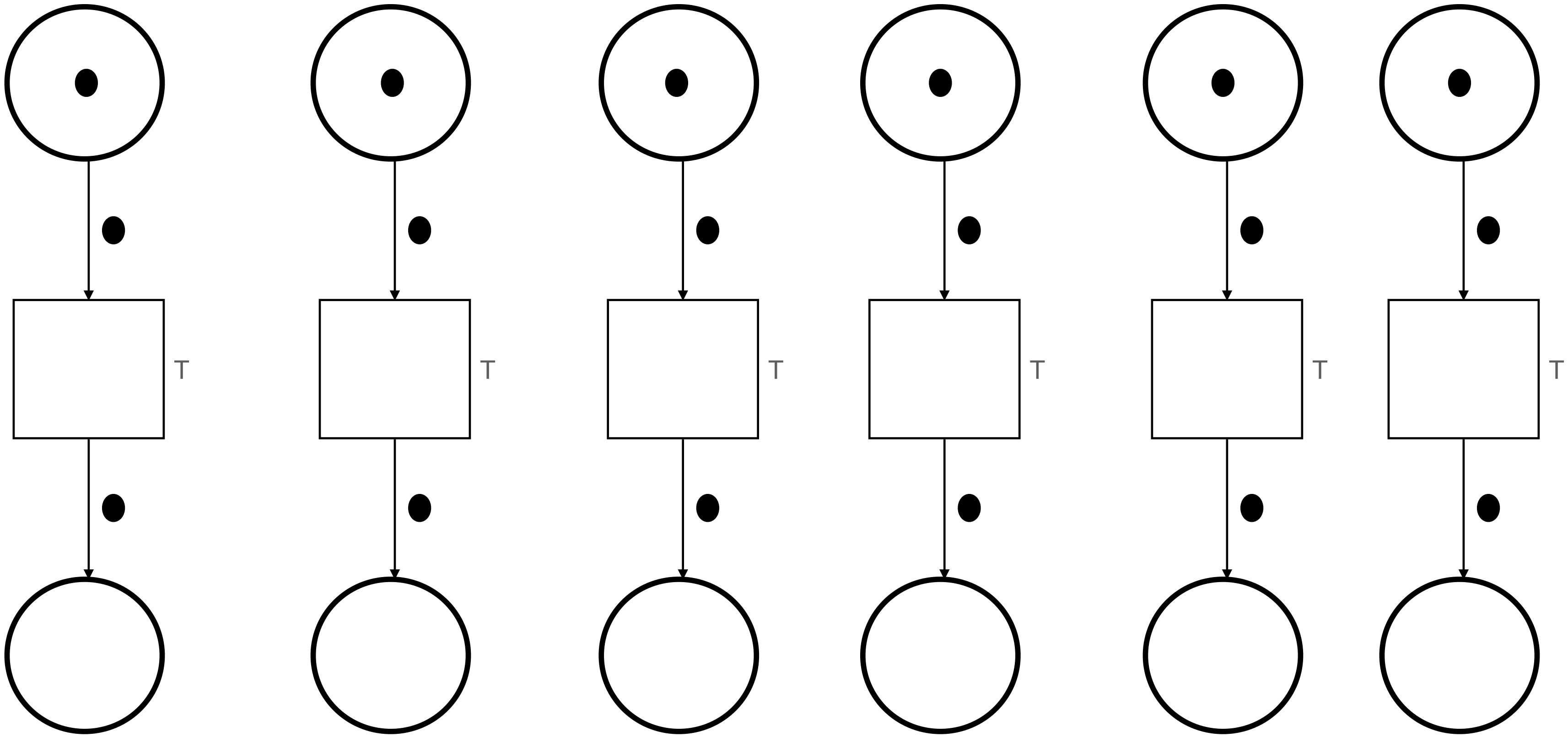
QUESTION TIME

What about now?



QUESTION TIME

What about now?



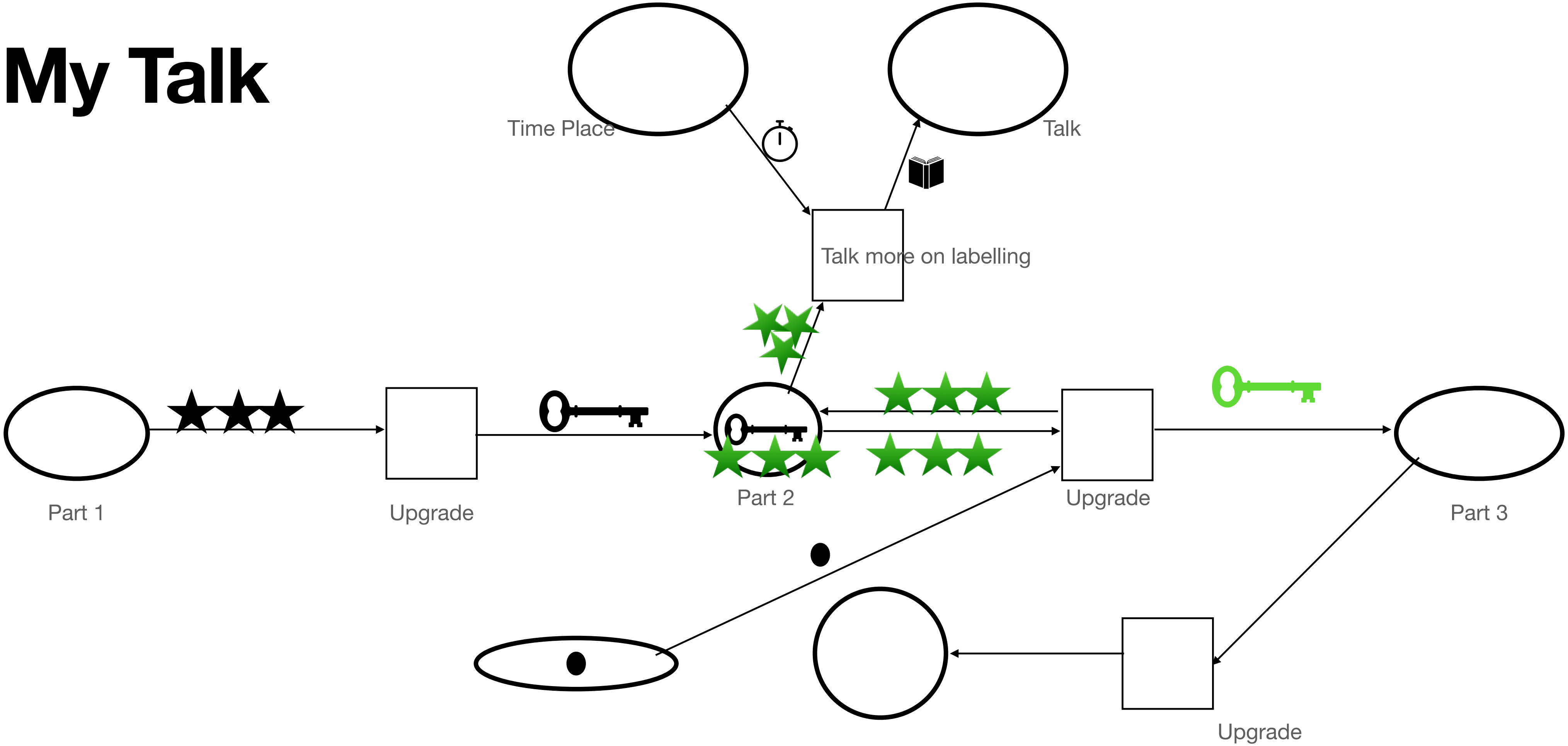
Part 2 Take Away

Components of
Net

Multiset as special data
Structure used
By Petri Nets

Non-graphical
representation
Of Marking

My Talk



Time Place
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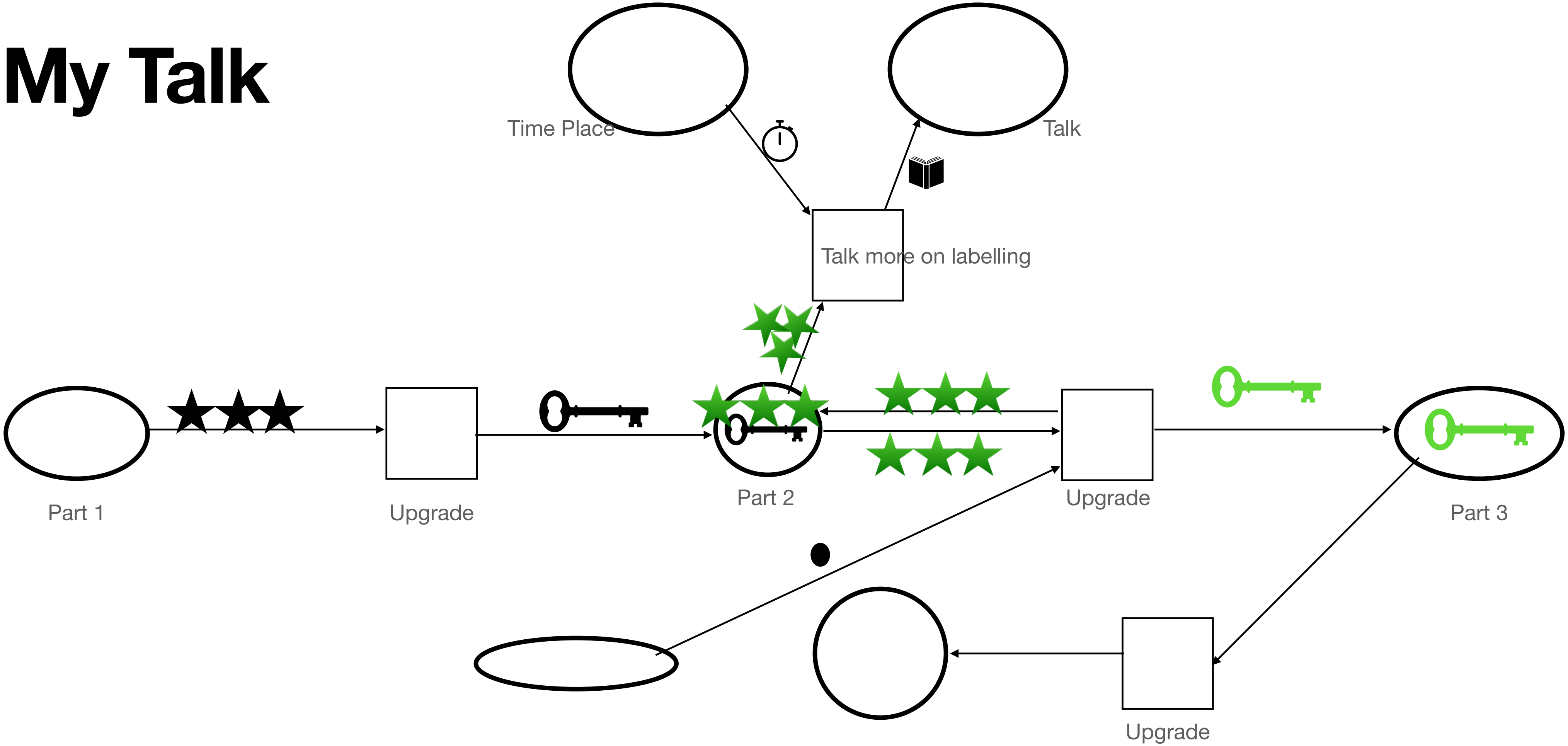
My Talk


Time Place
Talk
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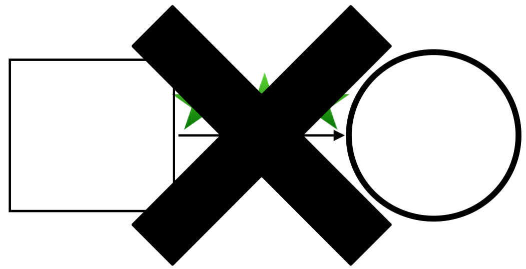
Part 1
Upgrade
Part 2
Upgrade
Part 3
Upgrade

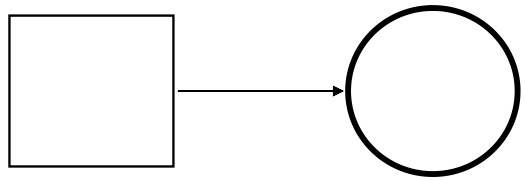
Part 3: Elementary system nets

- Part1, Part2: Generic System Nets
- Part3: Elementary System Nets

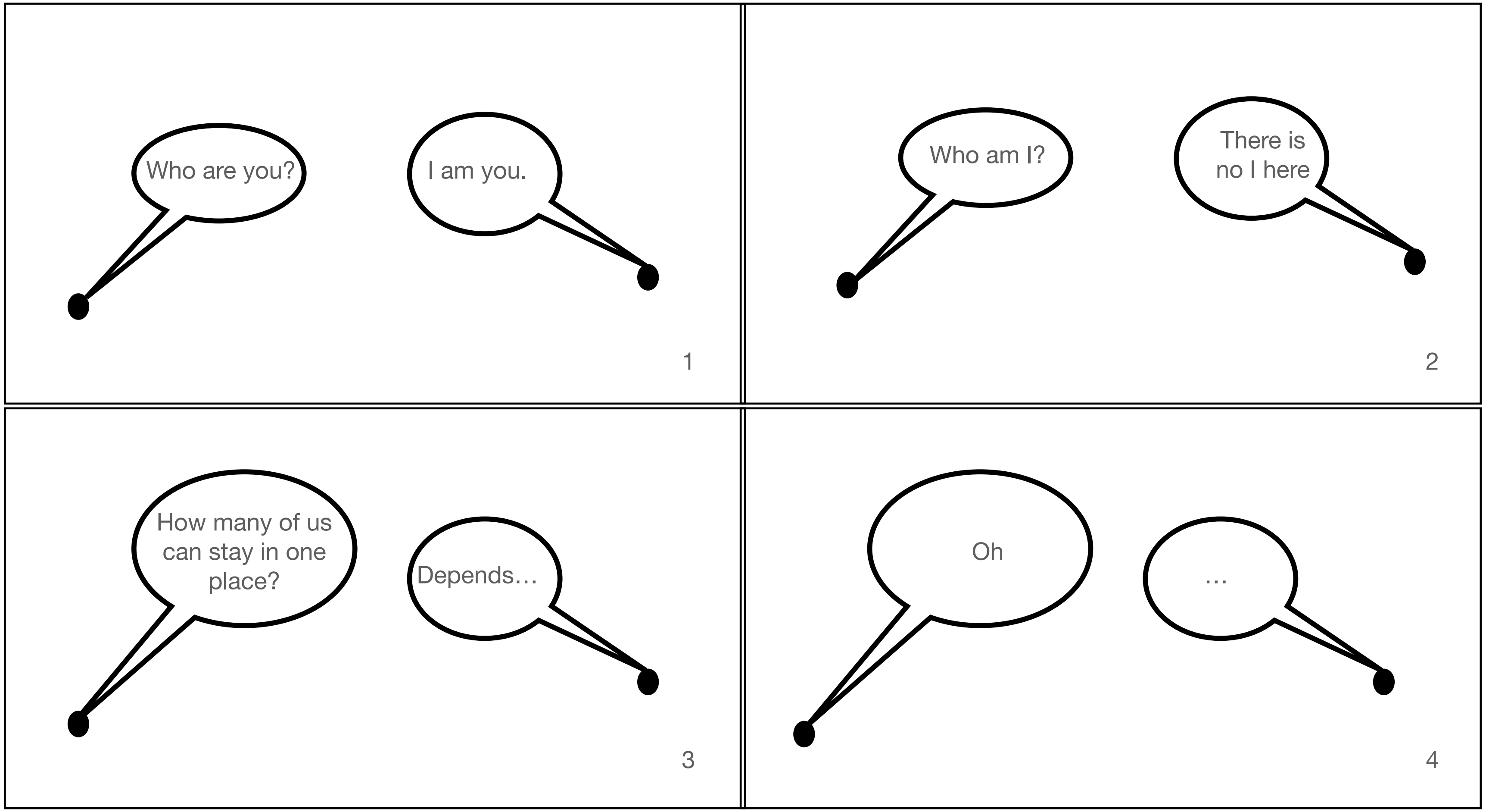
Part 3: Elementary system nets

- 2 Difference
  - Abstract Black Dot Token ONLY
  - No labelling: default is ●





Part 3: Elementary system nets



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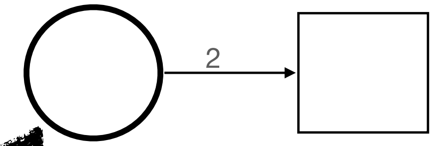
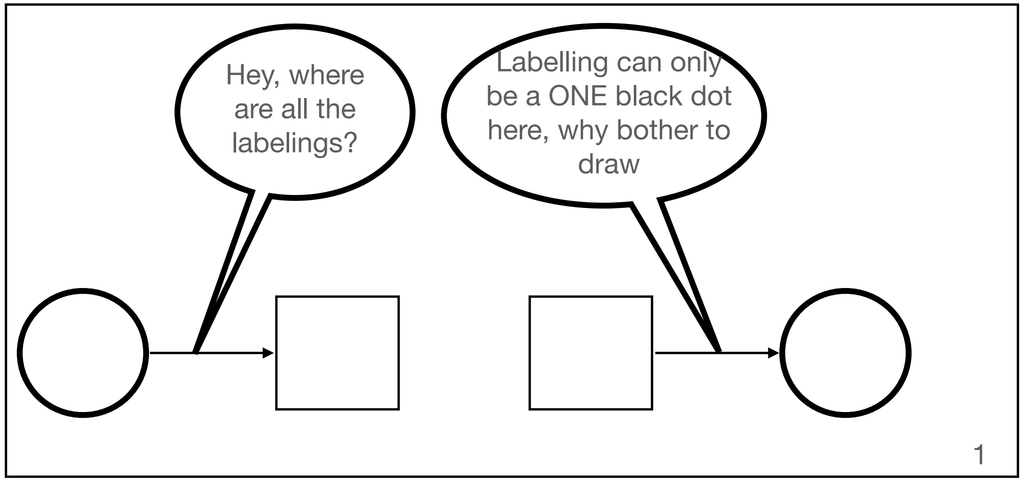
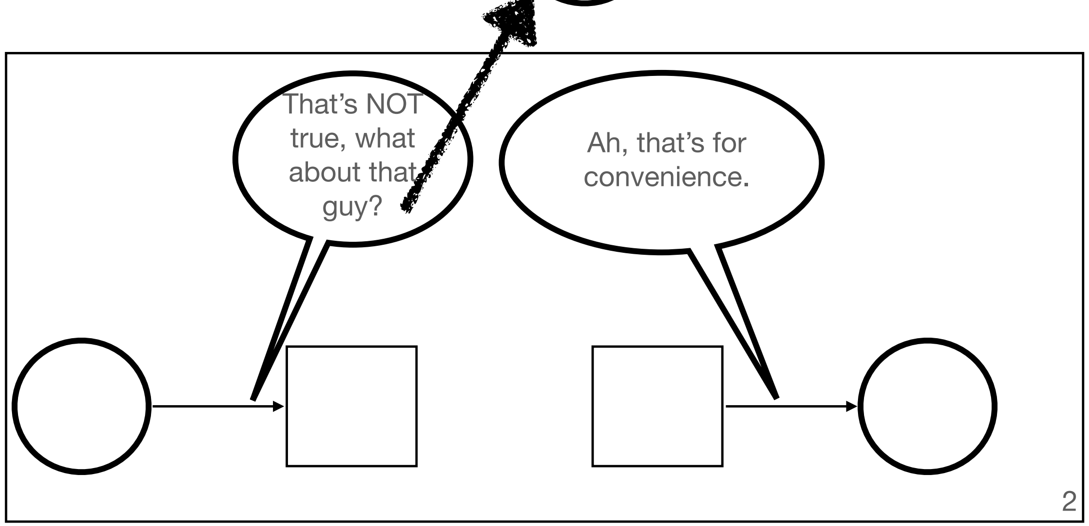
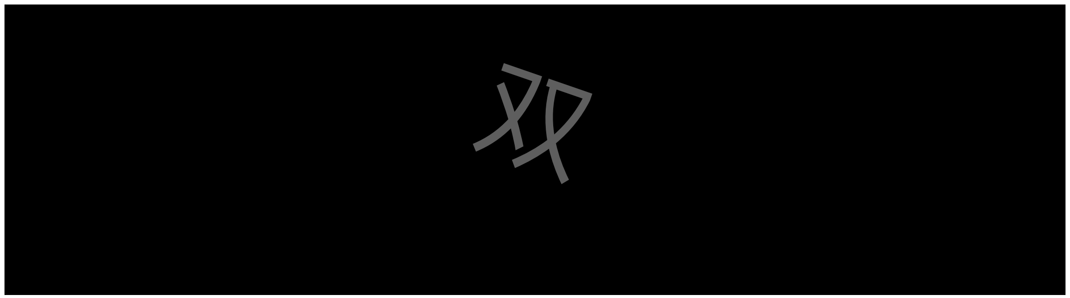
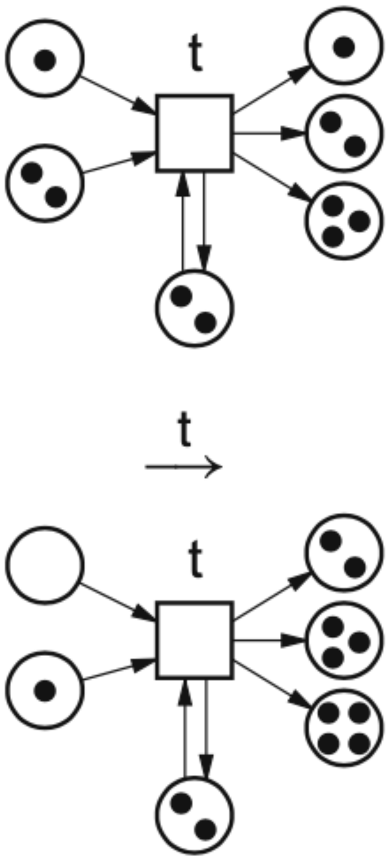








Part 3: Elementary system nets



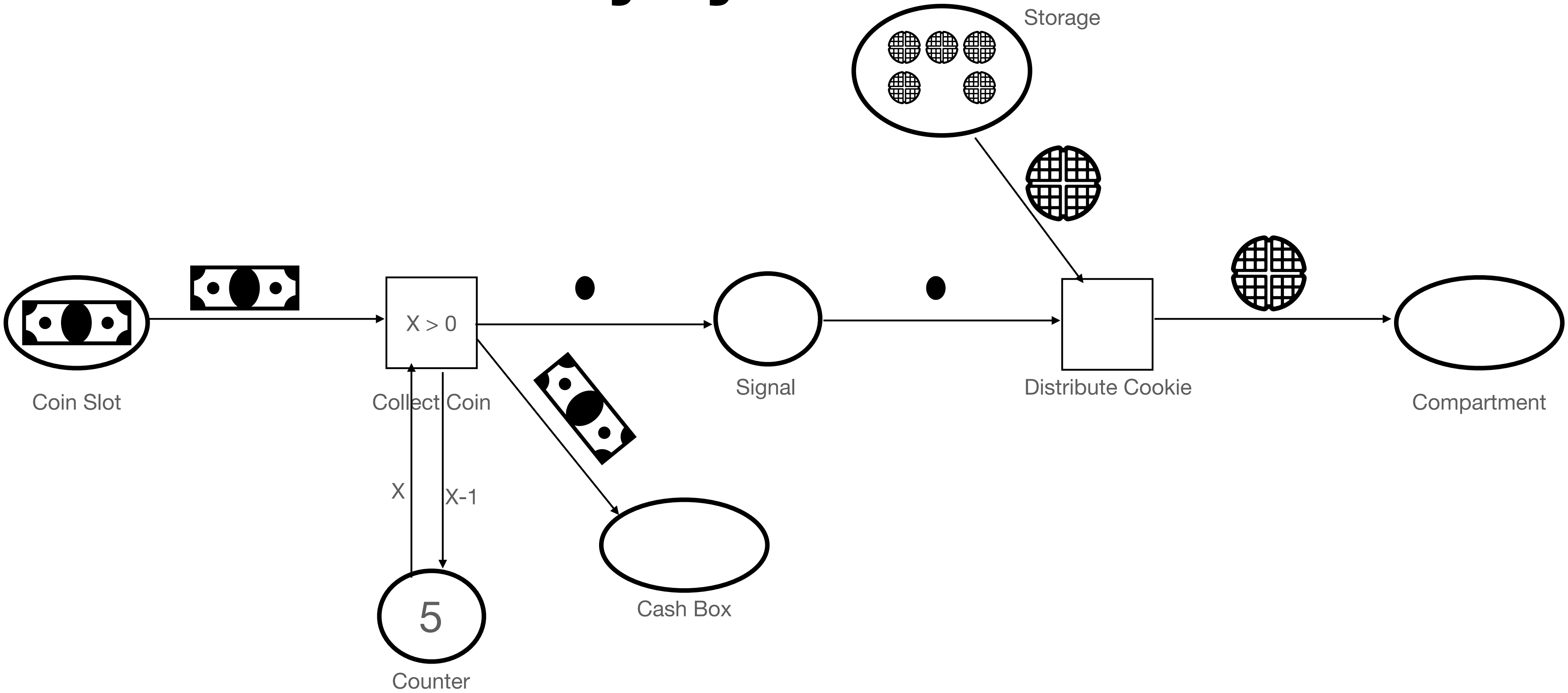
$$M'(p) = \begin{cases} M(p) - 1 & \text{if } \; p \in {}^{\bullet}t \text{ and } \; p \notin t^{\bullet} \\ M(p) + 1 & \text{if } \; p \in t^{\bullet} \text{ and } \; p \notin {}^{\bullet}t \\ M(p) & \text{otherwise} \end{cases}$$

Step Rule

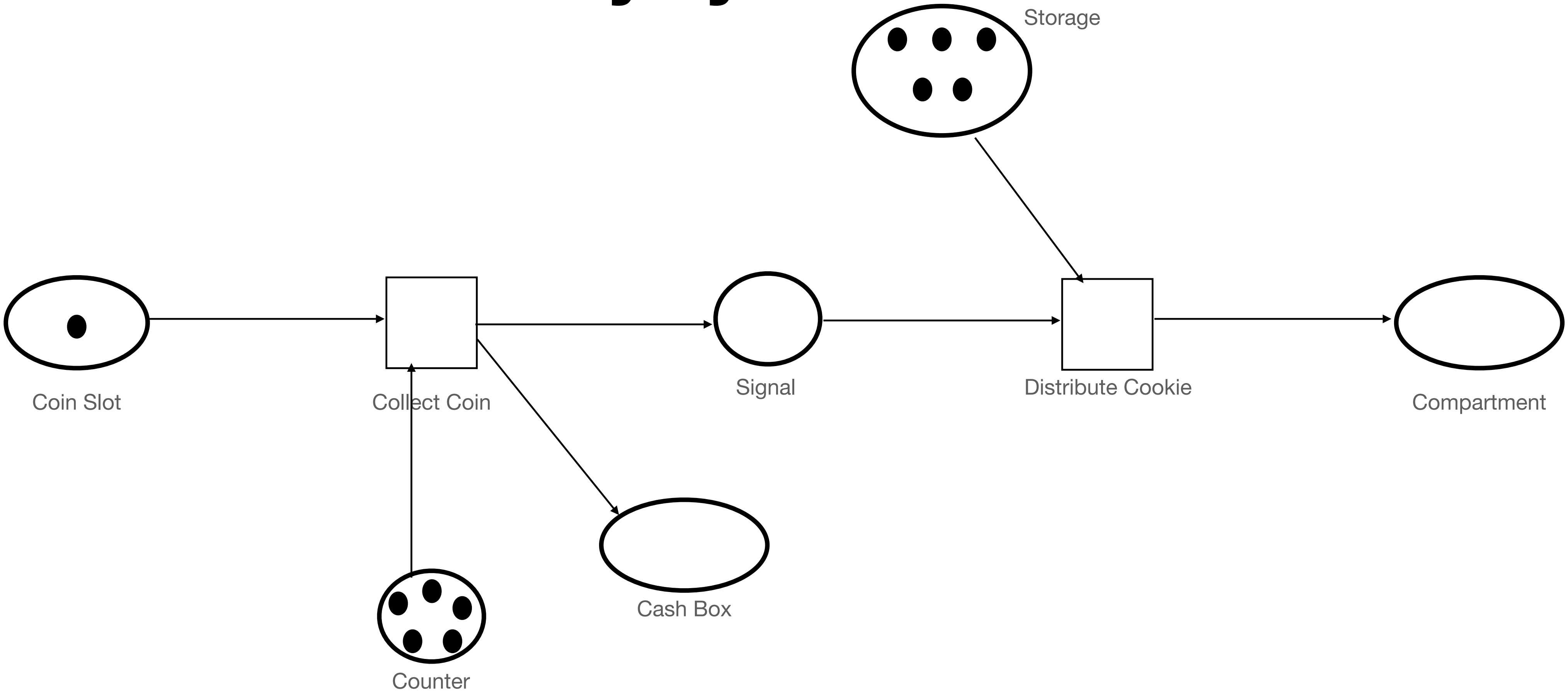
$$M_0 \xrightarrow{t_1} M_1 \xrightarrow{t_2} \dots \xrightarrow{t_n} M_n$$

(Wolfgang, 26)

Part 3: Elementary system nets



Part 3: Elementary system nets

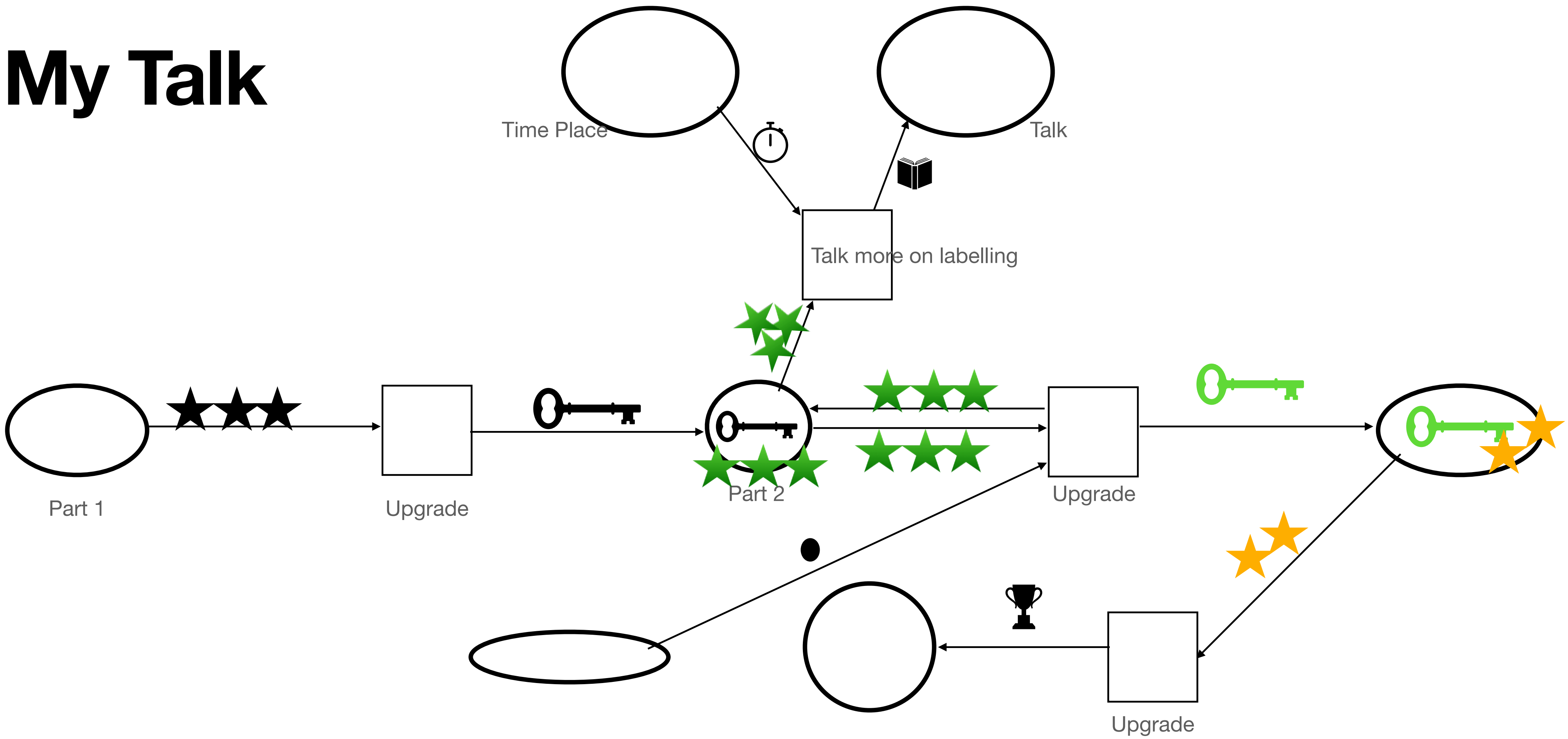


Part 3 Take Away

Generic System Nets
Vs
Elementary System Nets

Comfortable constructing
Simple petri nets
For fun

My Talk


Time Place
Talk
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Part 1
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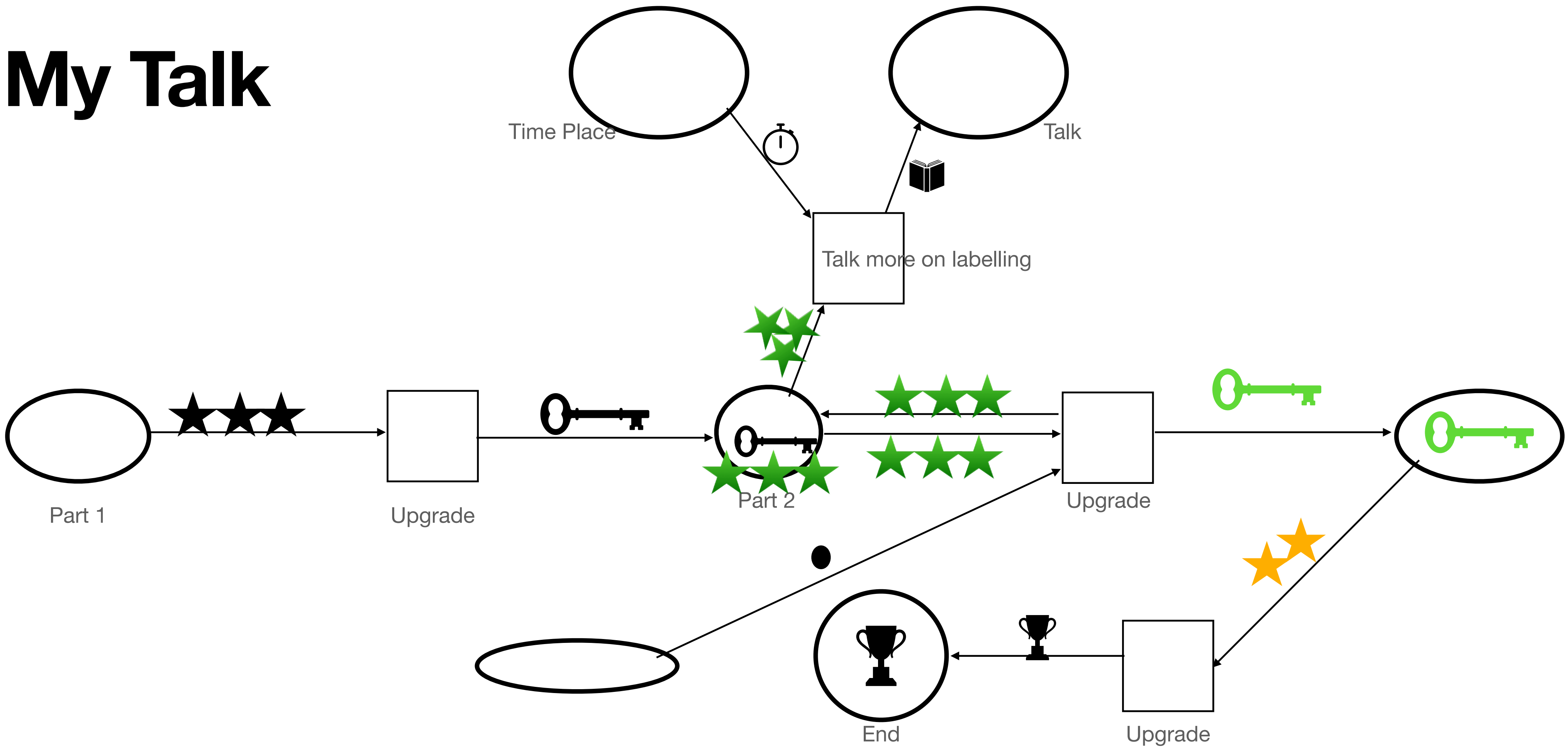
Upgrade

My Talk


Time Place
Talk
Talk more on labelling
Part 1
Upgrade
Part 2
Upgrade
Upgrade
End

More...

Part 4 Sth interesting if we have time

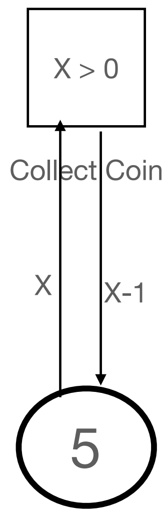
- Labelling (Generic System Nets)
- Petri Net modelling ME
- Code and Hot Transition
- Petri Net Modelling Relay Race
- Petri Net modelling Vivian_reading_books_unless_rain
- Some interesting design in cookie vending machine

Part 4 Sth interesting if we have time

- **Labelling of Arcs**
  - "Represent the tokens that flow through the arc at the occurrence of transition." (Wolfgang, 16)

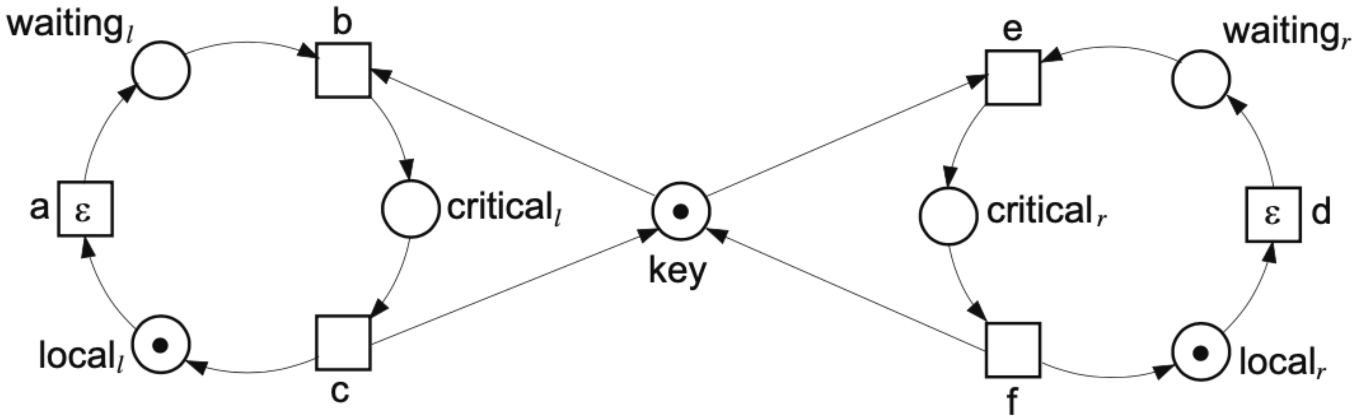
$$\overline{pt} \text{ or } \overline{tp}$$

  - NOT REAL TOKENs
    - Constant
    - Variable/Function



- **Labelling of Transitions**
  - Condition with variable.
  - Evaluated to True or False

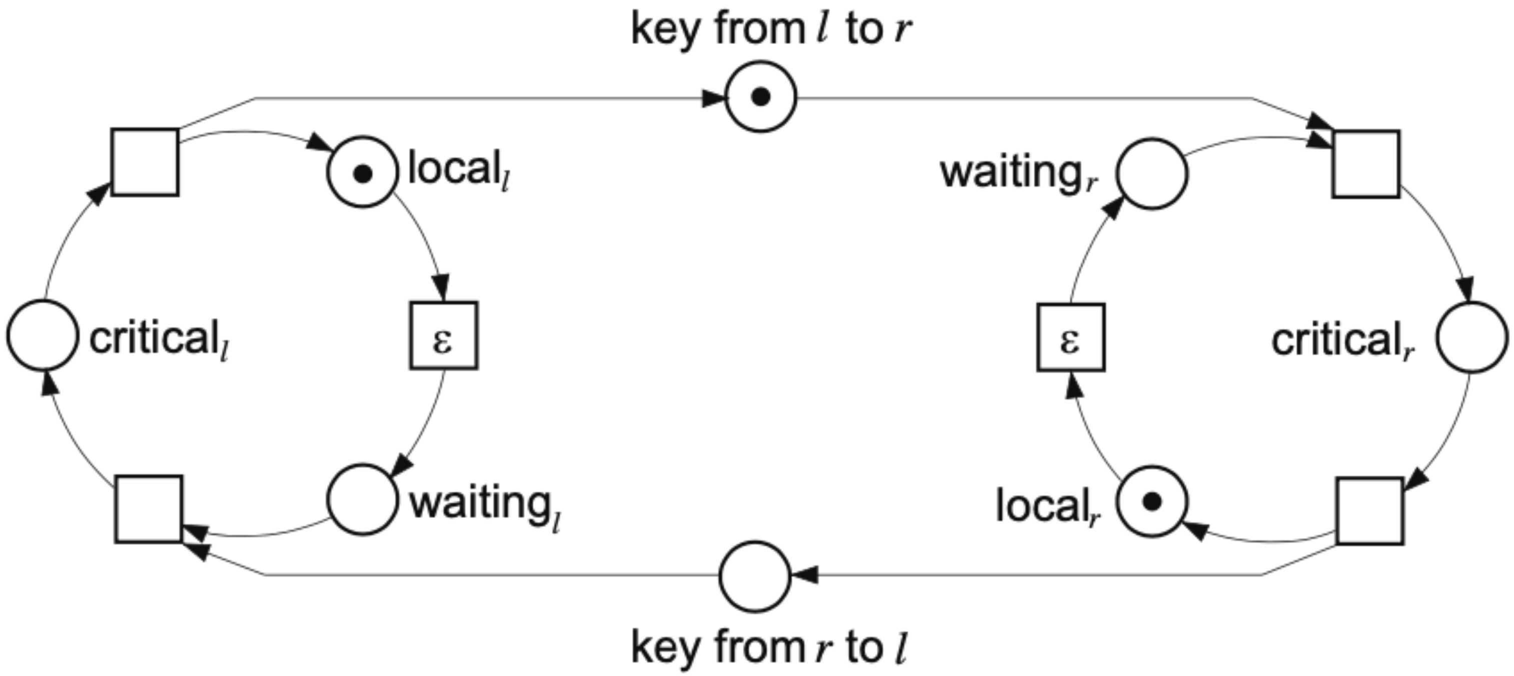
Part 4 Sth interesting if we have time



(Wolfgang, 27)

Models ME using elementary system nets. Find sth wrong here?

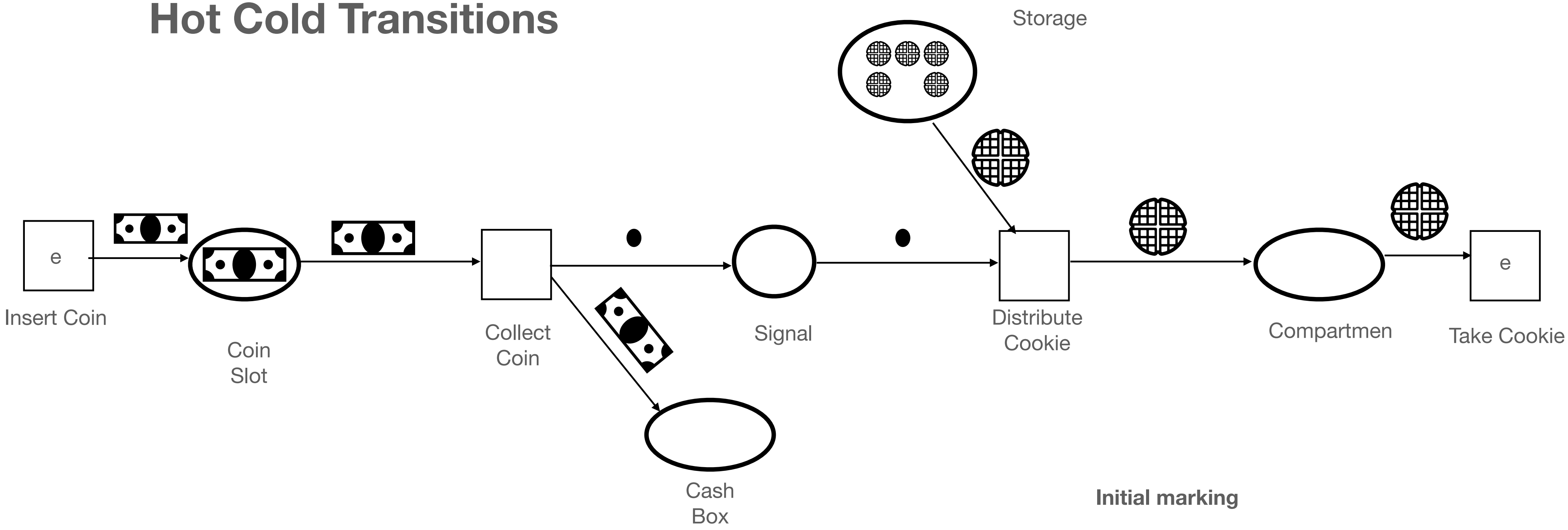
Part 4 Sth interesting if we have time



(Wolfgang, 28)

Part 4 Sth interesting if we have time

Hot Cold Transitions



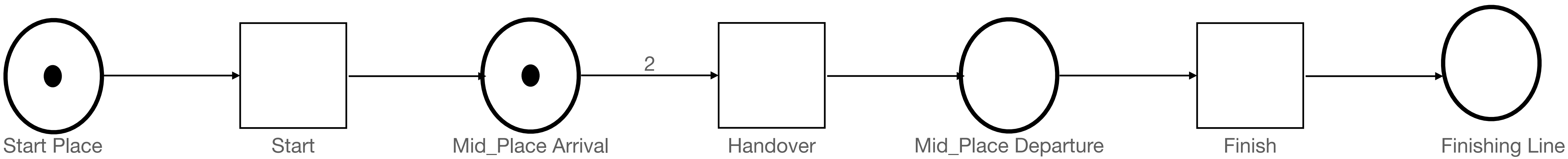
Initial marking

Part 4 Sth interesting if we have time

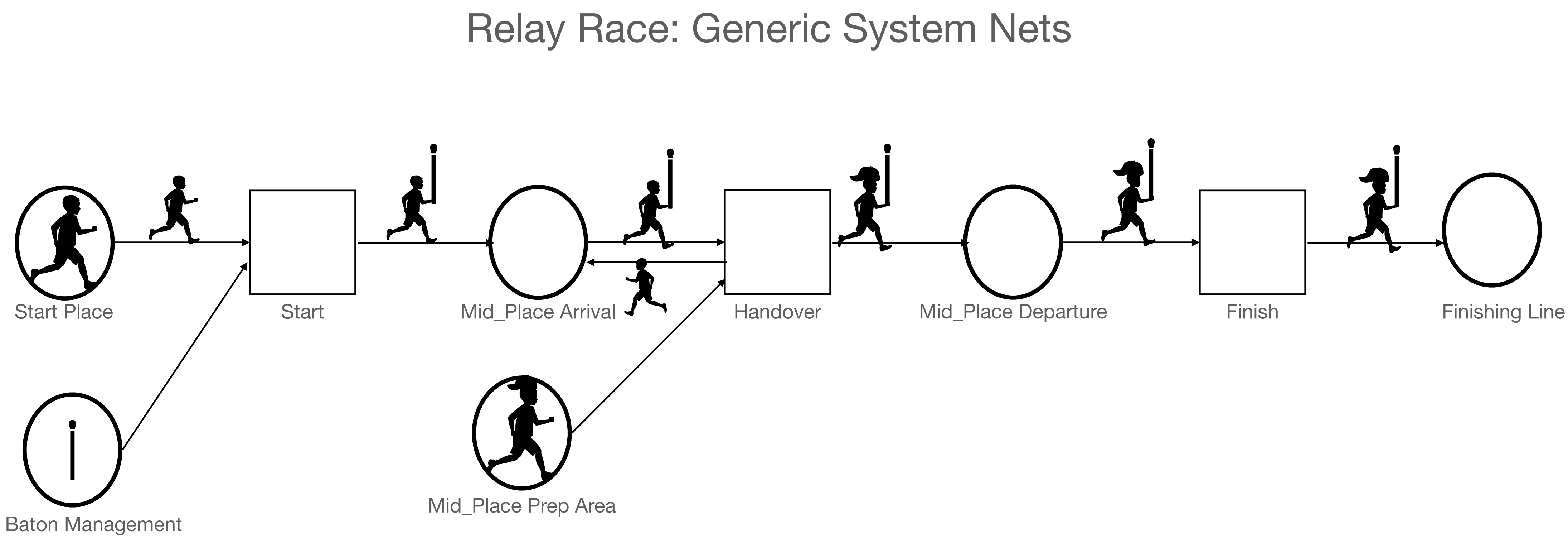
Relay Race: Process Graph

Part 4 Sth interesting if we have time

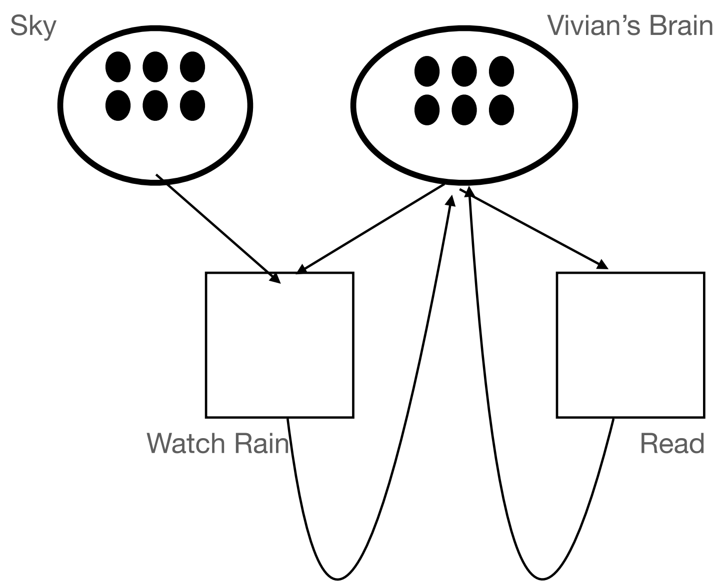
Relay Race: Elementary System Nets



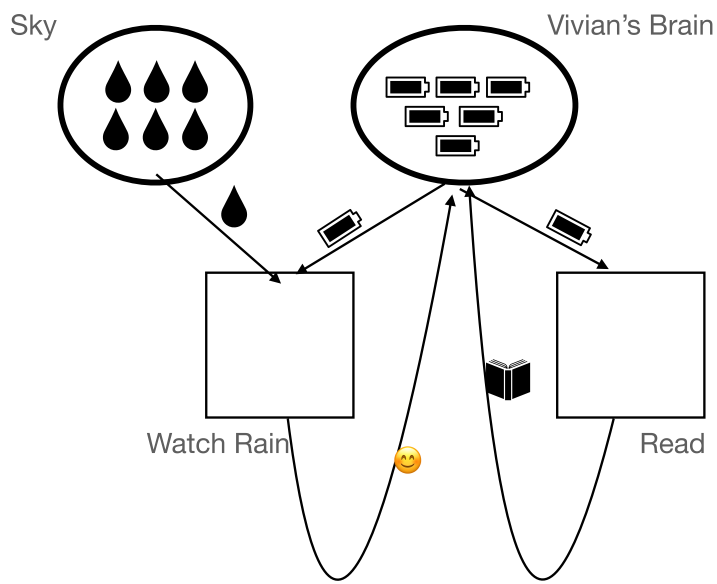
Part 4 Sth interesting if we have time



Part 4 Sth interesting if we have time



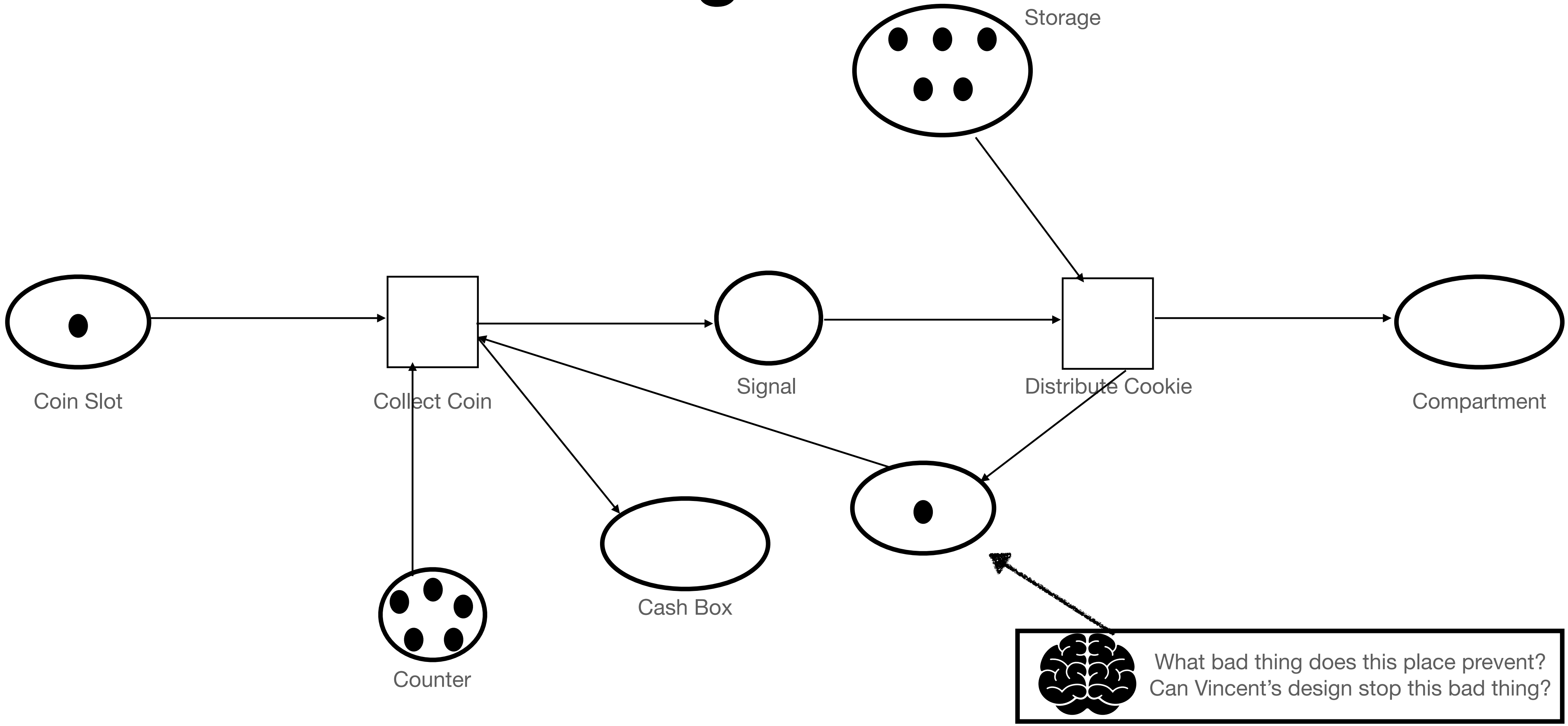
Elementary System Nets



Generic System Nets

Models Vivian's Read_book_unless_rainy days

Part 4 Sth interesting if we have time



Links to recordings

References

My talk covers all chapter 1, almost all in chapter 2 and about half of chapter 3. The book is available in UNSW library and it’s a fun read.

Reisig, Wolfgang. Understanding Petri Nets : Modeling Techniques, Analysis Methods, Case Studies. Berlin, Heidelberg: Springer Berlin Heidelberg : Imprint: Springer, 2013. Print.

Thank you!

:D

Drop me an email if you got any question:
tiankuang.zhang@student.unsw.edu.au