# GlobalDataLoader in Multi DeepLearning Task

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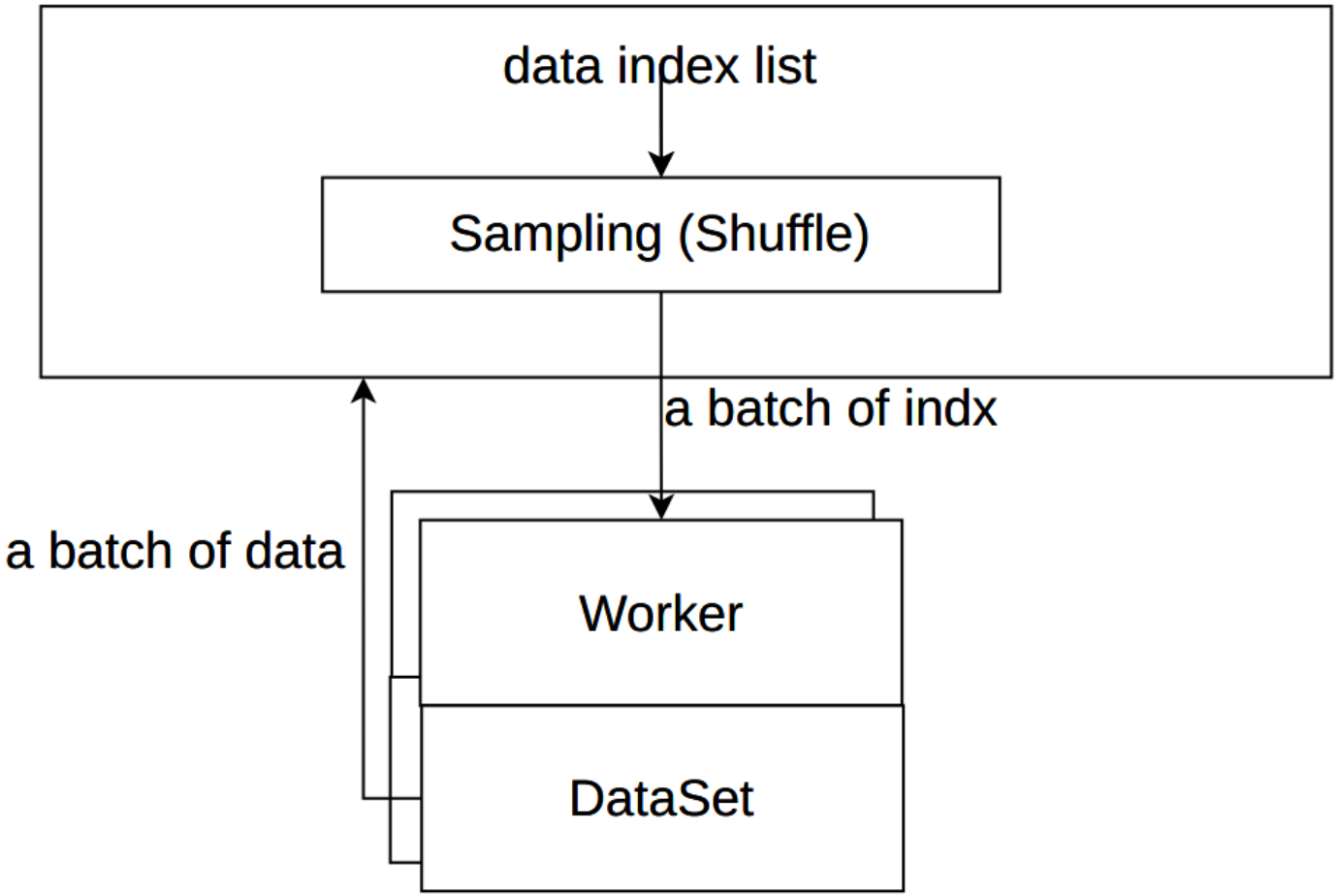
# DataLoader in Pytorch



# Problem: Repeated Reading and Processing

## Situation

To compare the performance of different algorithms, Many DeepLearning tasks are training in the same Dataset.

## Problem

Every task has its own DataLoader. So the data will be repeatedly read and processed by different tasks.

## Result

As the number of tasks increases, so does the training time. And what increases is the time to load the data

# Experiment

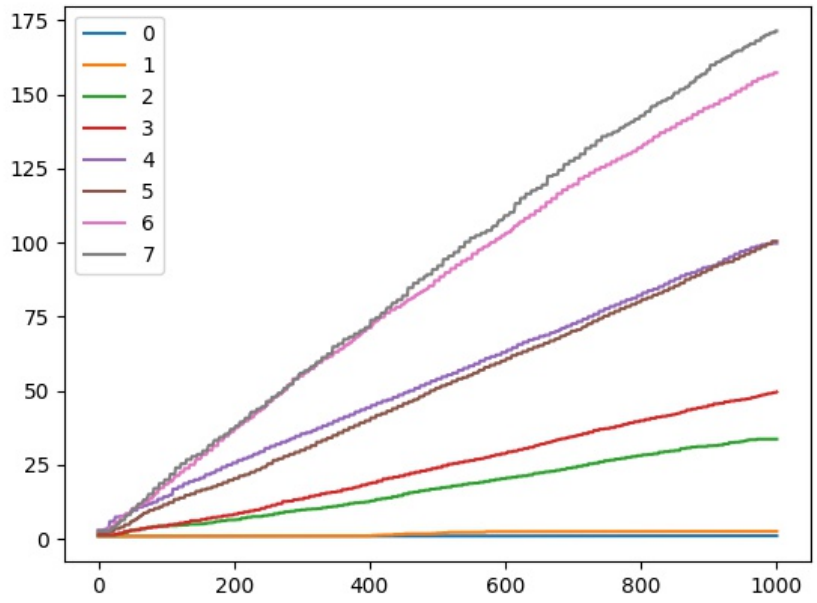



Figure: data loading time

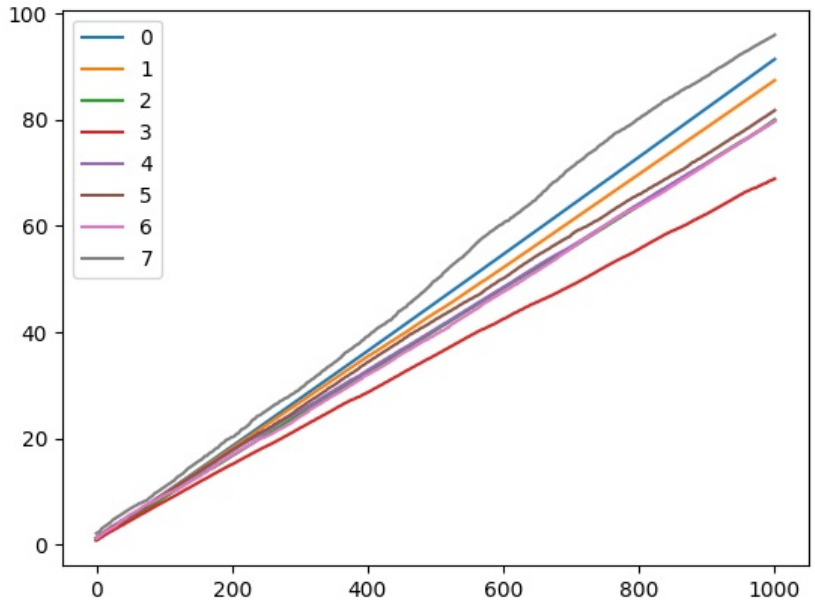



Figure: data training time

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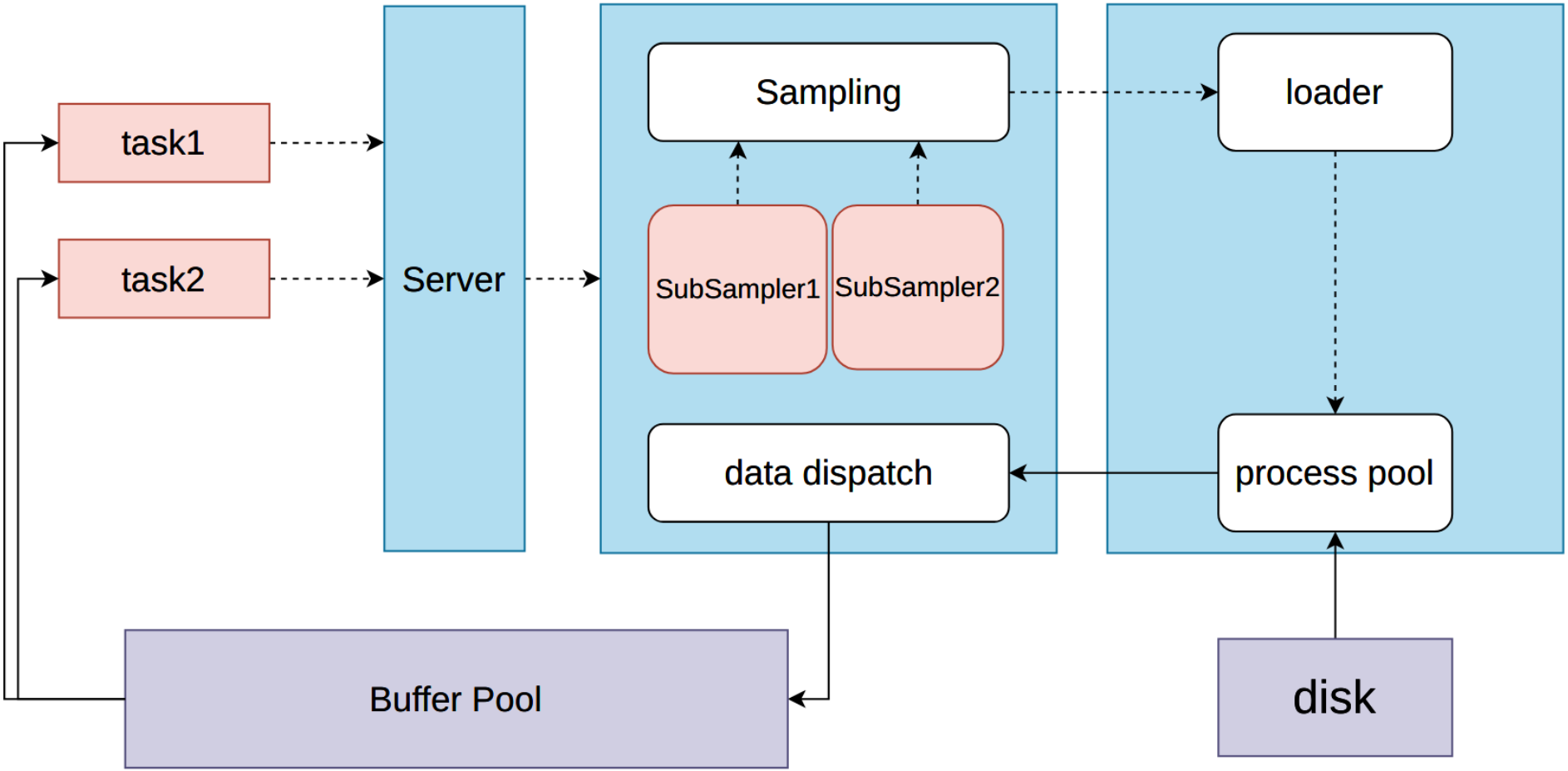
# Architecture



# Sampling: problem description

## Defination

For a single task, the sampler needs to select an index from the index set $S$.

Similarly, for multiple tasks, the sampler needs to select an index from multiple sets $\{S_1, S_2, ...\}$

## Requirments

- The index in the set $S$ should be randomly sampled. The probability of the index being selected is $1/|S|$
- Duplicate indexes need to be merged
- There can be no problem of "starvation"

# Assumption 1

**Requirments**

- There are only two sets $\{S_1, S_2\}$
- $S_1$ is same as $S_2$. And the length of $S_1$ and $S_2$ is n

# Solution 1

## description

In order to avoid the problem of "starvation", we sampling the idx through polling.

## steps

- First, We randomly select an idx $i_1$ from the $S_1$.
- Because $S_1$ and $S_2$ are the same, we don't need to sample $S_2$

# Assumption 2

**Requirments**

- There are only two sets $\{S_1, S_2\}$
- $S_1$ and $S_2$ are equal in length, which is $n$
- The intersection of $S_1$ and $S_2$ is $S_i$, whose length is $n_i$

# Solution 2

**steps**

- First, We randomly select an idx $i_1$ from the $S_1$.
- If $i_1 \in S_2$ then we do nothing like solution 1
- If $i_1 \notin S_2$ then we randomly select an idx $i_2$ from the $S_2 - S_1$

# Proving

## S1

$p(idx_1) = \frac{1}{n}$

## S2

If $idx_2 \in S_i$,

$$p(idx_2) = \frac{n_i}{n} * \frac{1}{n_i} = \frac{1}{n}$$

If $idx_2 \notin S_i$,

$$p(idx_2) = \frac{n - n_i}{n} * \frac{1}{n - n_i} = \frac{1}{n}$$

# Assumption 3

## Requirments

- There are only two sets $\{S_1, S_2\}$
- $S_1$ is different from $S_2$, and their length are $n_1$ and $n_2$
- The intersection of $S_1$ and $S_2$ is $S_i$, whose length is $n_i$

# Solution 3

If we use Solution2.

## S2

If $idx_2 \in S_i$,

$$p(idx_2) = \frac{n_i}{n_1} * \frac{1}{n_i} = \frac{1}{n_1}$$

If $idx_2 \notin S_i$,

$$p(idx_2) = \frac{n_1 - n_i}{n_1} * \frac{1}{n2 - n_i} = \frac{n_1 - n_i}{n_1 * (n_2 - n_i)}$$

# Solution 3

if $n_1 < n_2$, then $p(idx_2 \in S_i) > \frac{1}{n_2}$. So in step 2 of Solution2, we should randomly select a idx in $S_2 - S_i$ in probability of $x$.

f $idx_2 \in S_i$,

$$p(idx_2) = \frac{n_i}{n_1} * (1 - x) * \frac{1}{n_i} = \frac{1}{n_2}$$

If $idx_2 \notin S_i$,

$$p(idx_2') = \frac{n_1 - n_i}{n_1} * \frac{1}{n2 - n_i} + \frac{n_i}{n_1} * x * \frac{1}{n2 - n_i} = \frac{1}{n_2}$$

then

$$x = \frac{n_2 - n_1}{n_2}$$

# Solution 3

if $n_1 > n_2$, then $p(idx_2 \notin S_i) > \frac{1}{n_2}$. So in step 3 of Solution2, we should randomly select a idx in $S_i$ in probability of $x$.

f $idx_2 \in S_i$,

$$p(idx_2) = \frac{n_i}{n_1} * \frac{1}{n_i} + x * \frac{n1 - n_c}{n1} * \frac{1}{n_i} = \frac{1}{n_2}$$

If $idx_2 \notin S_i$,

$$\frac{n1 - n_i}{n1} * \frac{1}{(n2 - n_i)} * (1 - x) = \frac{1}{n2}$$

then

$$x = 1 - \frac{n_1 * (n_2 - n_i)}{n_2 * (n_1 - n_i)}$$

# Solution 3

## steps

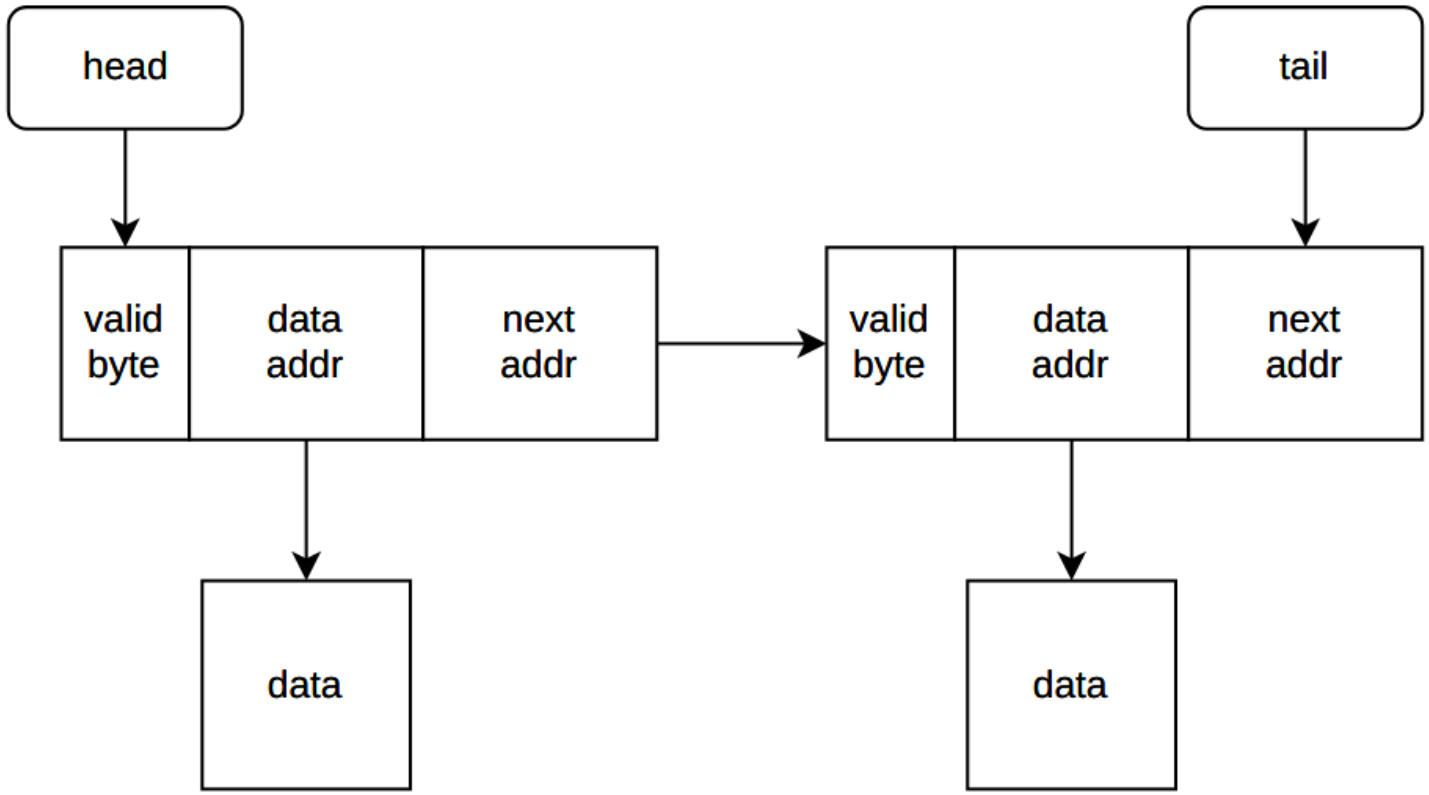
- First, We randomly select an idx $i_1$ from the $S_1$.
- If $i_1 \in S_2$ and $n_1 < n_2$, randomly sample in $S_2 - S_i$ with a probability of $\frac{n_2 - n_1}{n_2}$
- If $i_1 \in S_2$ and $n_1 > n_2$, do nothing
- If $i_1 \notin S_2$ and $n_1 > n_2$ randomly sample in $S_2 - S_i$ with a probability of $1 - \frac{n_1 * (n_2 - n_i)}{n_2 * (n_1 - n_i)}$
- If $i_1 \notin S_2$ and $n_1 < n_2$ do nothing

# Data Structure

# Insert

# Sample

# Buffer Pool: Data Structure

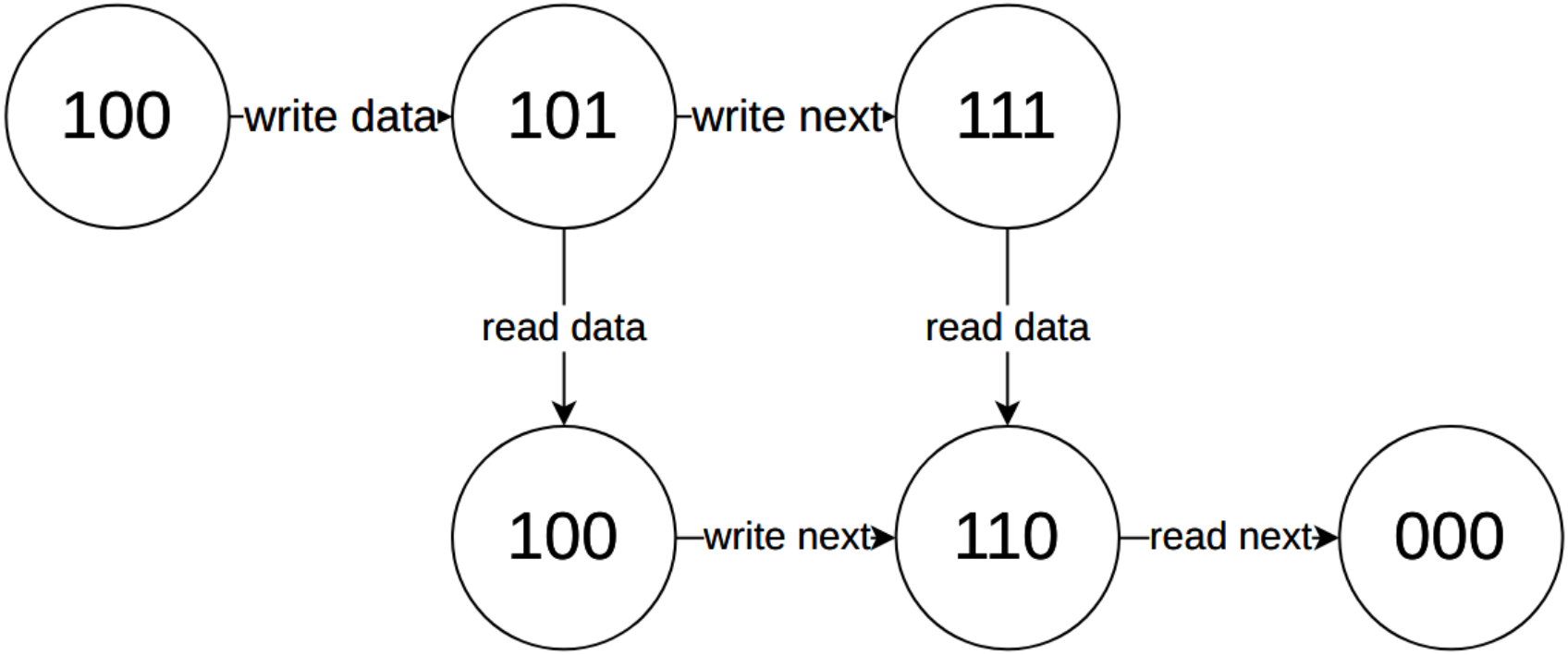


# Buffer Pool: Valid Byte

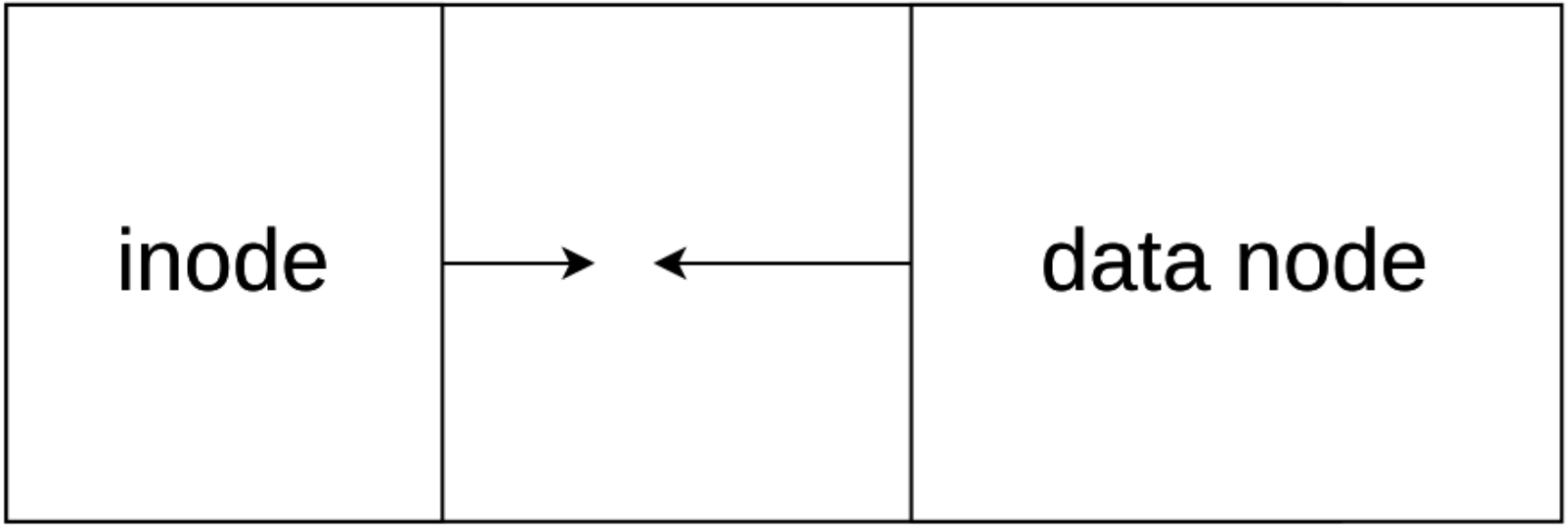
**valid byte**

- data bit: If the data bit is equal to 1, the data addr is valid. Otherwise invalid
- next bit: If the next bit is equal to 1, the next addr is valid. Otherwise invalid
- used bit: If the used bit is equal to 1, this inode is used by some tasks

# Buffer Pool: Automata



# Buffer Pool: Address Space



# Buffer Pool: allocate inode

# Buffer Pool: allocate data node

# Buffer Pool: write

# Buffer Pool: read

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# Experiment

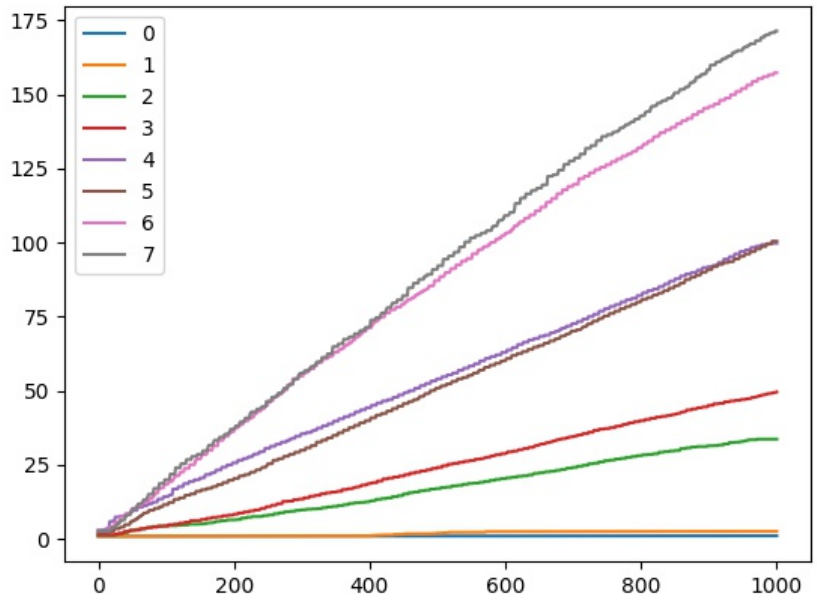


Figure: time

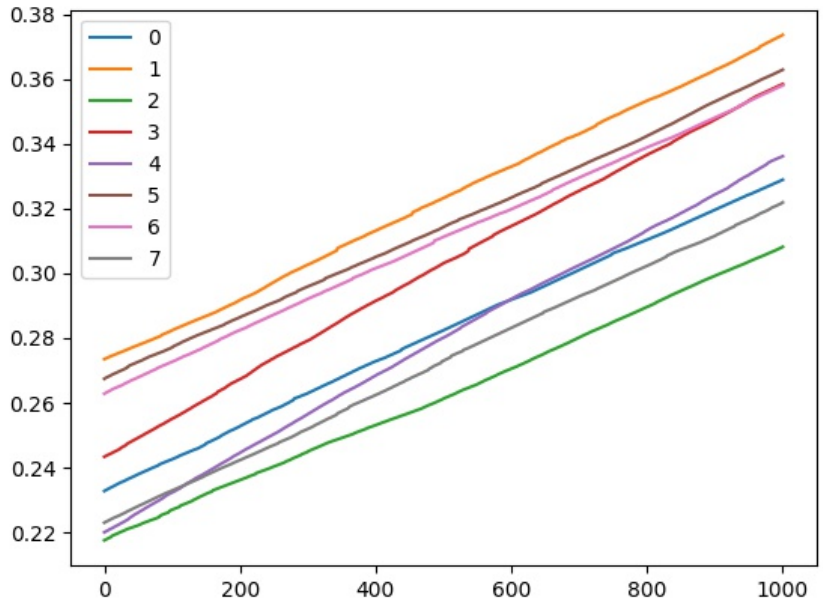


Figure: time with GlobalDataLoader