分布式训练系列

集合通信原语

ZOMI

关于本内容

1. 内容背景

- AI集群+大模型+分布式训练系统

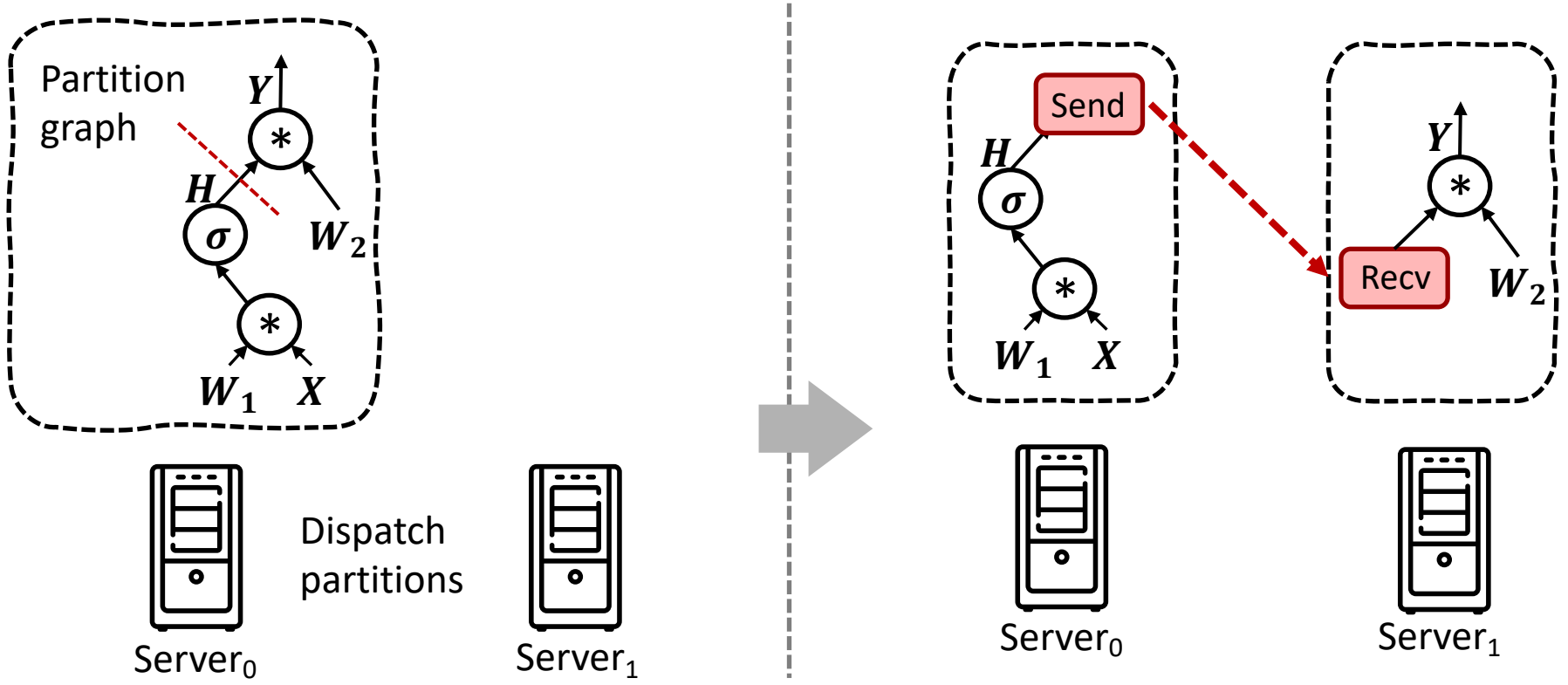
2. 具体内容

- **AI集群服务器架构：**参数服务器模式 – 同步与异步并行 - 环同步算法
- **AI集群软硬件通信：**通信软硬件实现 - 通信实现方式
- **分布式通信原语：**通信原语
- **框架分布式功能：**并行处理硬件架构 – AI框架中的分布式训练

- **大模型算法：**挑战 – 算法结构 – SOTA大模型
- **分布式并行：**数据并行 – 张量并行 – 自动并行 – 多维混合并行

分布式训练系统

- 计算图跨节点切分



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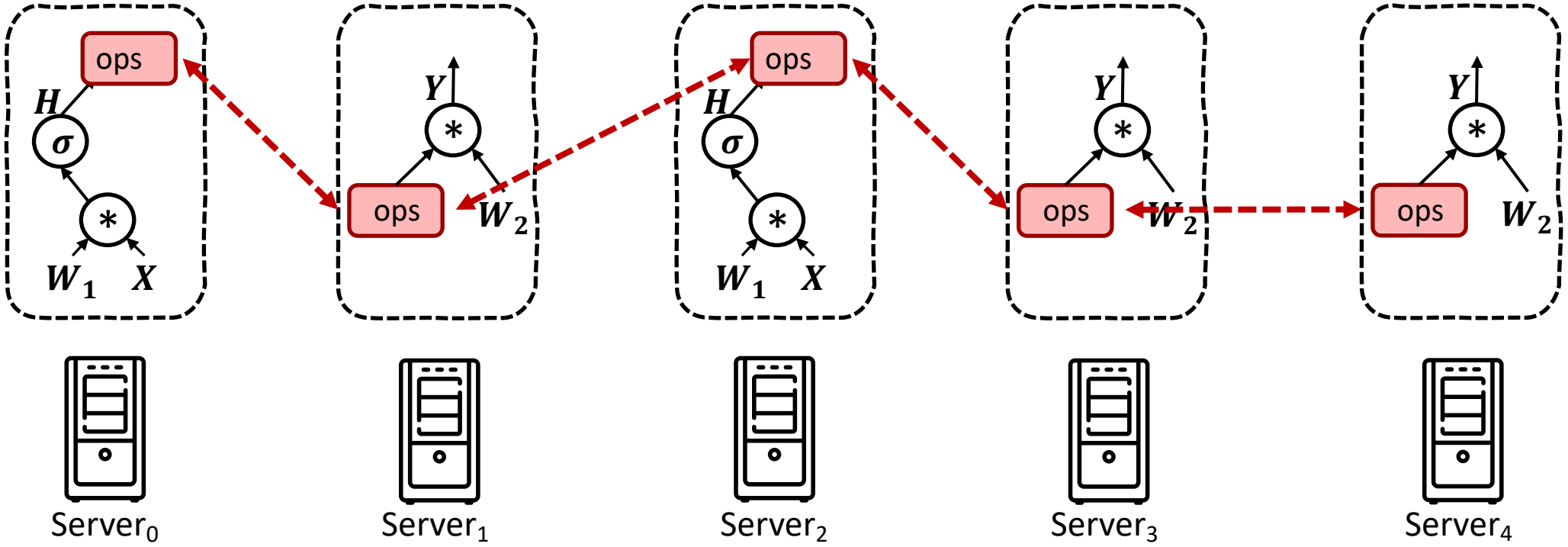
分布式训练系统

- 计算图跨节点同步数据（权重weights）信息



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分布式训练系统（II）

PyTorch

- 示例：分布式MNIST

```
""" Distributed Synchronous SGD Example """
def run(rank, size):
    torch.manual_seed(1234)
    train_set, bsz = partition_dataset()
    model = Net()
    optimizer = optim.SGD(model.parameters(),
                          lr=0.01, momentum=0.5)

    num_batches = ceil(len(train_set.dataset) / float(bsz))
    for epoch in range(10):
        epoch_loss = 0.0
        for data, target in train_set:
            optimizer.zero_grad()
            output = model(data)
            loss = F.nll_loss(output, target)
            epoch_loss += loss.item()
            loss.backward()
            average_gradients(model)
            optimizer.step()
        print('Rank ', dist.get_rank(), ', epoch ',
              epoch, ': ', epoch_loss / num_batches)
```

```
""" Gradient averaging. """
def average_gradients(model):
    size = float(dist.get_world_size())
    for param in model.parameters():
        dist.all_reduce(param.grad.data, op=dist.reduce_op.SUM)
        param.grad.data /= size
```


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集合式通信方式

- 一对多：Scatter / Broadcast
- 多对一：Gather / Reduce
- 多对多：All-Reduce / All-Gather

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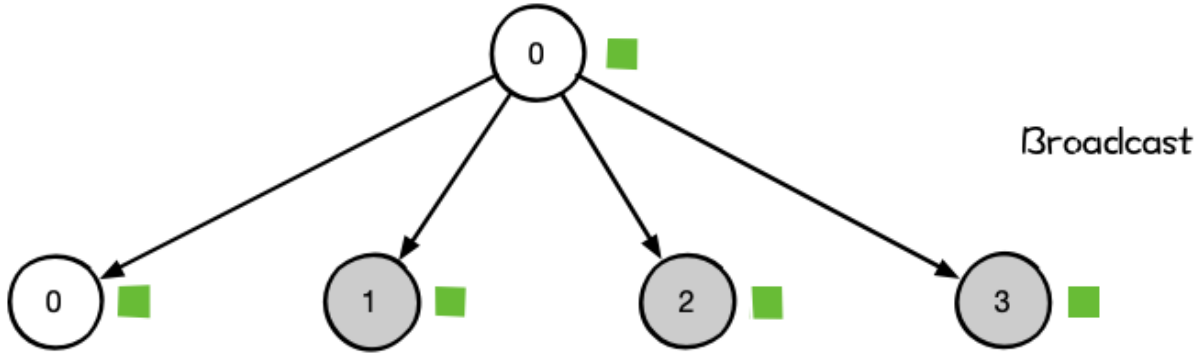
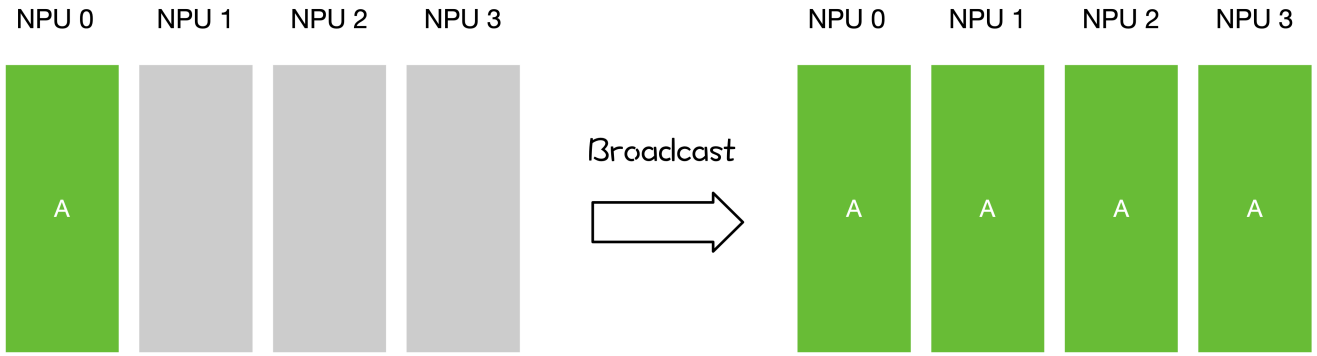
集合式通信方式 (I)：一对多 Broadcast

某个节点想把自身的数据发送到集群中的其他节点，那么就可以使用广播Broadcast的操作。

分布式机器学习中常用于网络参数的初始化。





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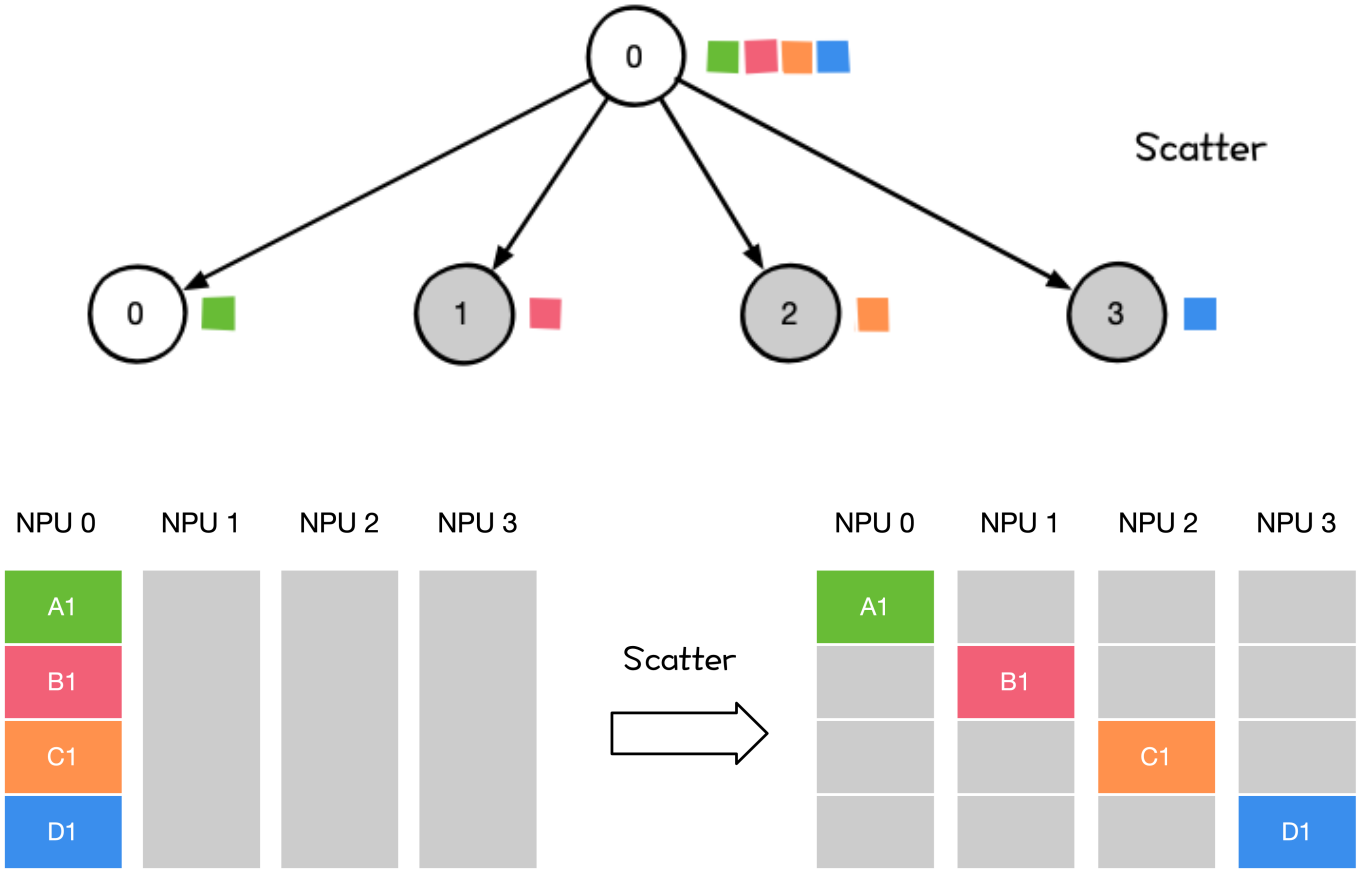
集合式通信方式 (I)：一对多 Scatter

将主节点的数据进行划分并散布至其他指定的节点。



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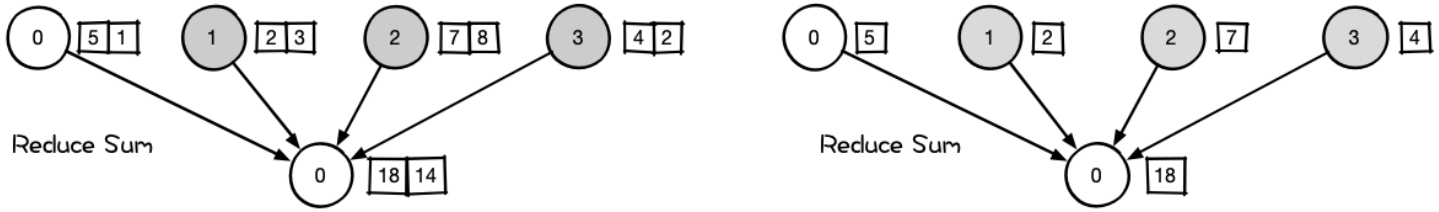
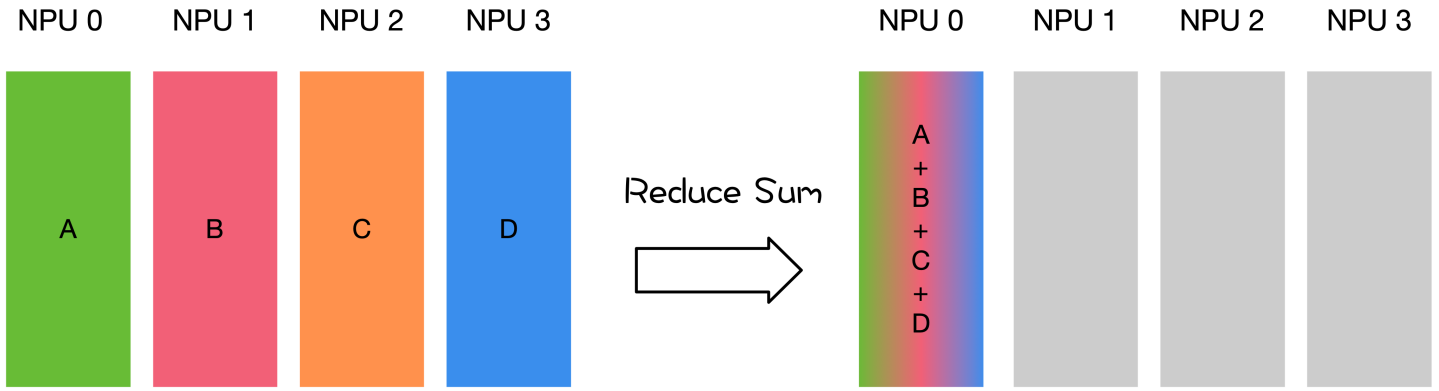
集合式通信方式 (II)：多对一 Reduce

Reduce 称为规约运算，是一系列简单运算操作的统称。

细分可以包括：SUM、MIN、MAX、PROD、LOR等类型的规约操作。





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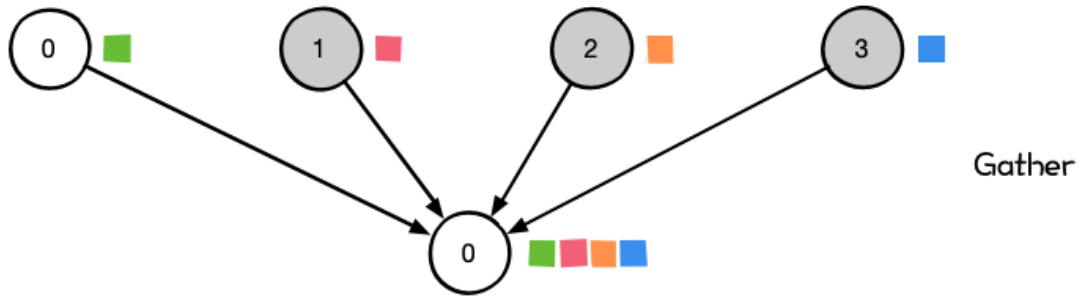
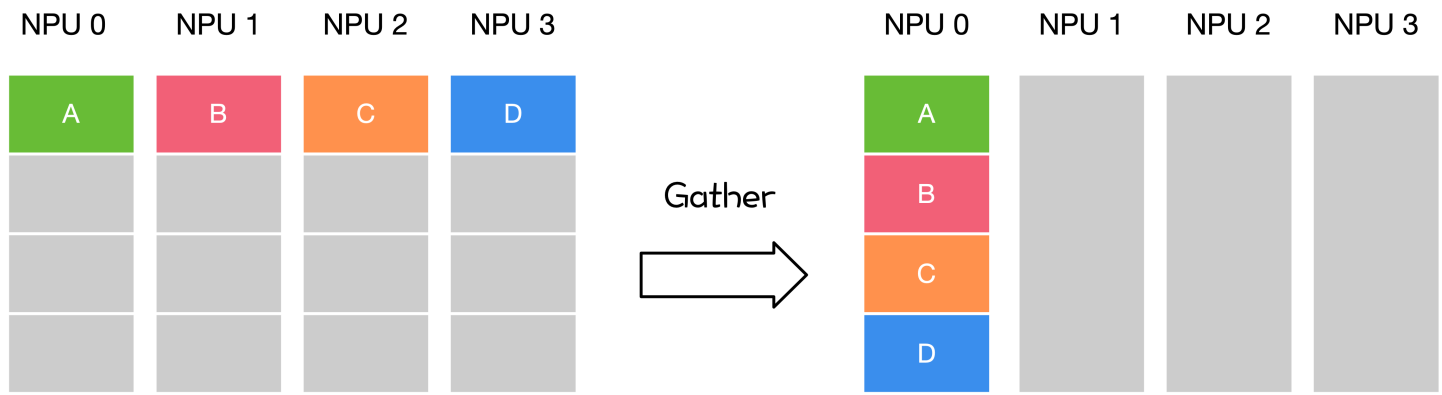
集合式通信方式 (II)：多对一 Gather

将多个 Sender 上的数据收集到单个节点上，Gather 可以理解为反向的 Scatter。

对很多并行算法很有用，比如并行的排序和搜索。





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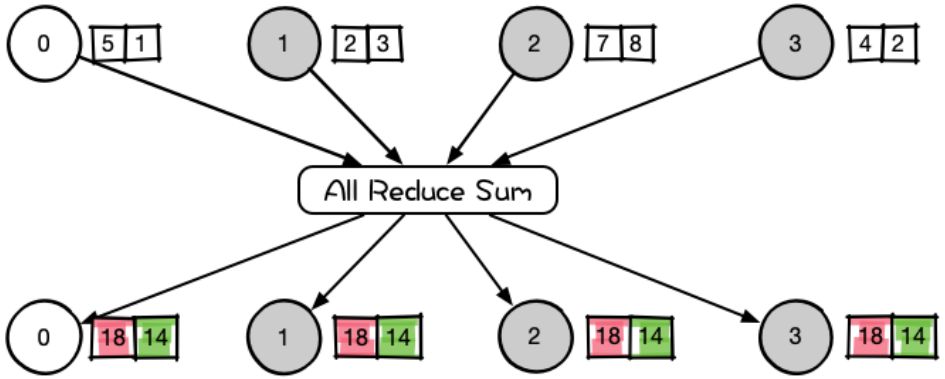
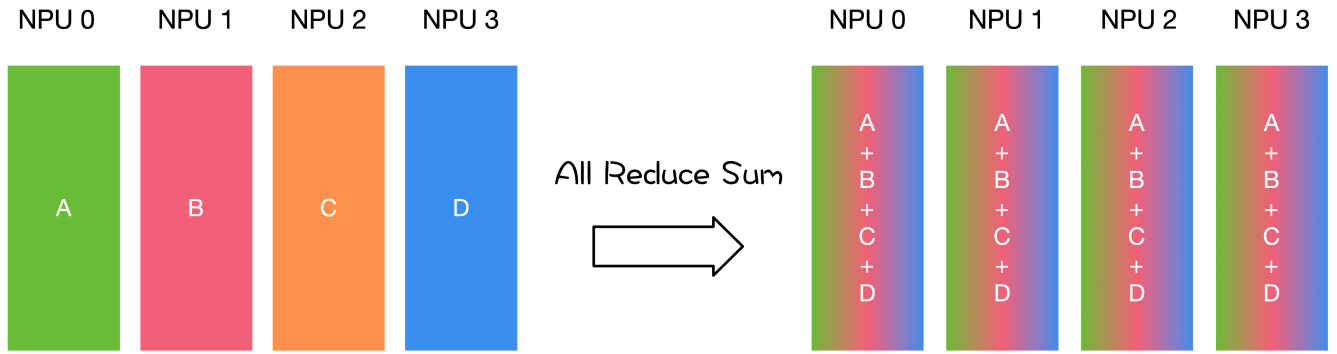
集合式通信方式 (III)：多对多 All Reduce

All Reduce则是在所有的节点上都应用同样的Reduce操作。

All Reduce操作可通过Reduce + Broadcast 或者 Reduce-Scatter + All-Gather 操作完成。





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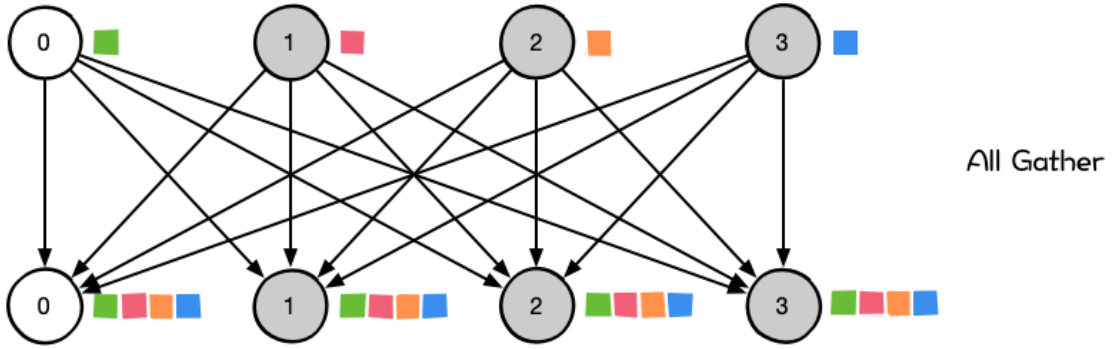
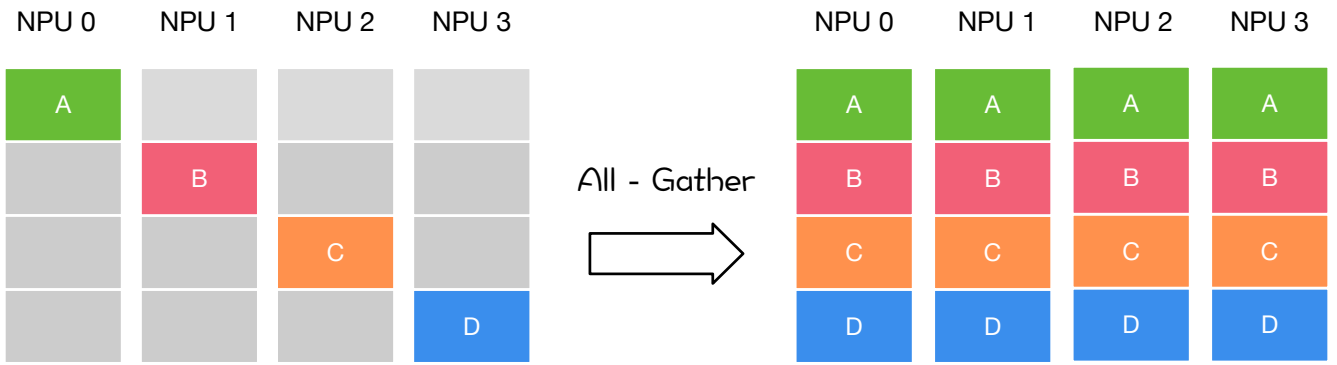
集合式通信方式 (III)：多对多 All-Gather

All Gather会收集所有数据到所有节点上。 All Gather = Gather + Broadcast。

发送多个元素到多个节点很有用，即在多对多通信模式的场景。





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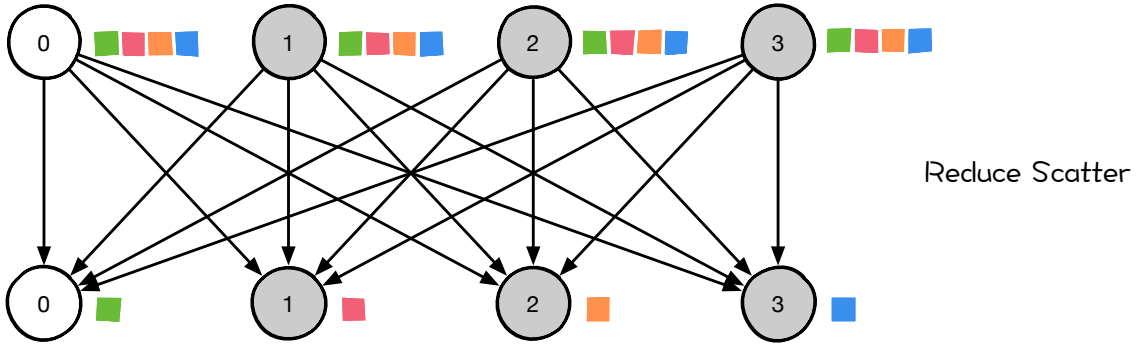
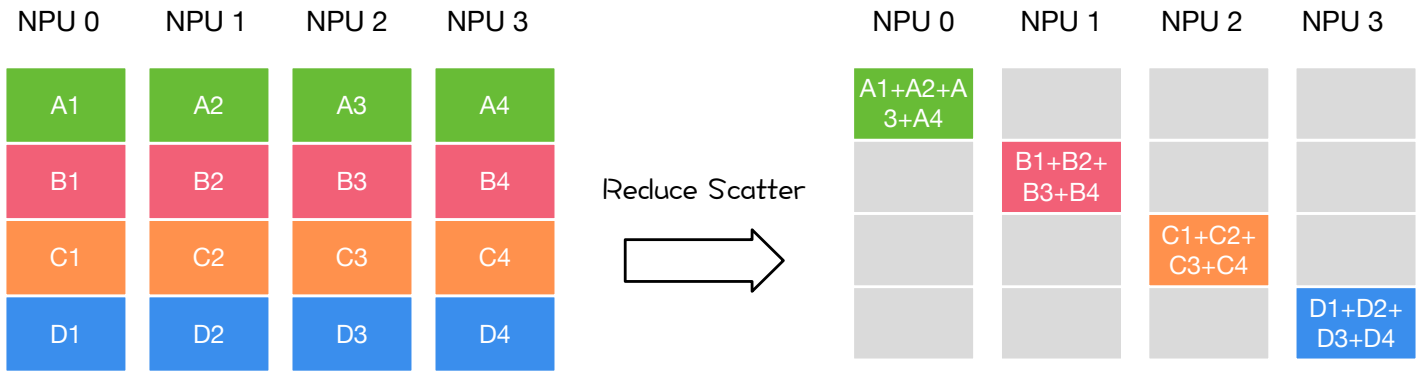
集合式通信方式 (III)：多对多 Reduce Scatter

Reduce Scatter操作会将个节点的输入先进行求和，然后在第0维度按卡数切分，将数据分发到对应的卡上。





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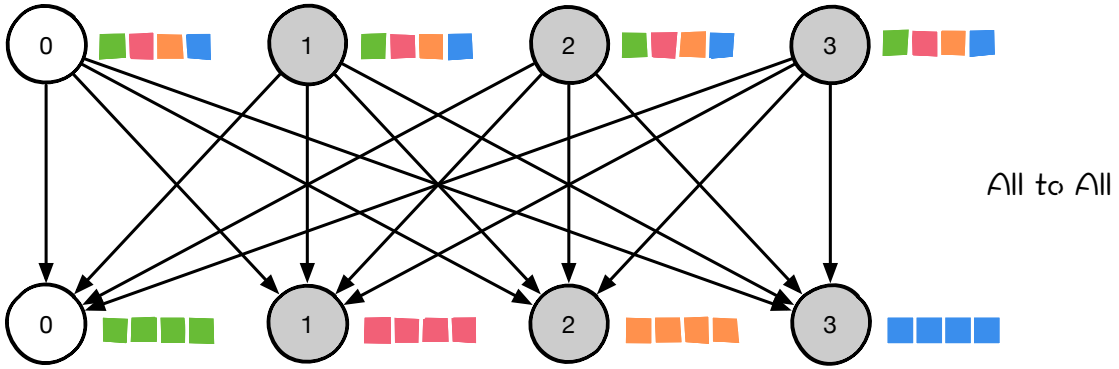
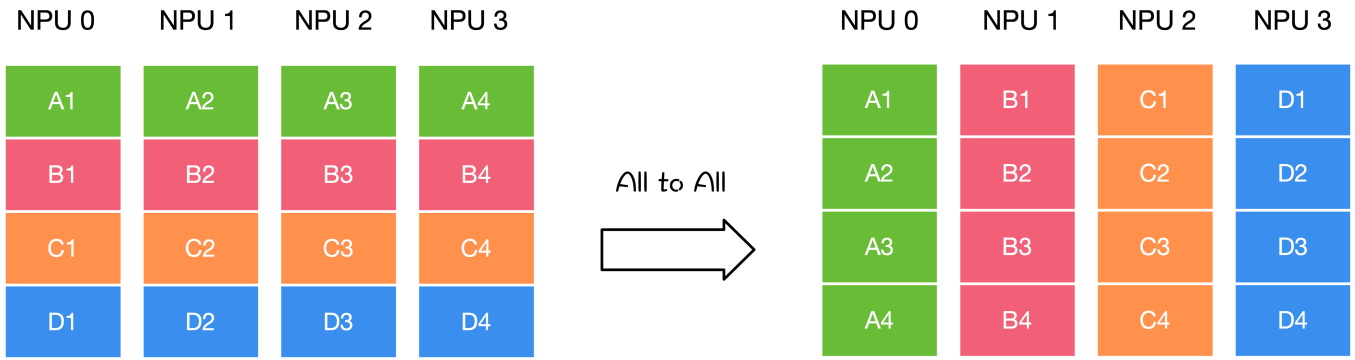
集合式通信方式 (III)：多对多 All to All

将节点i的发送缓冲区中的第j块数据发送给节点j，节点j将接收到的来自节点i的数据块放在自身接收缓冲区的第i块位置。





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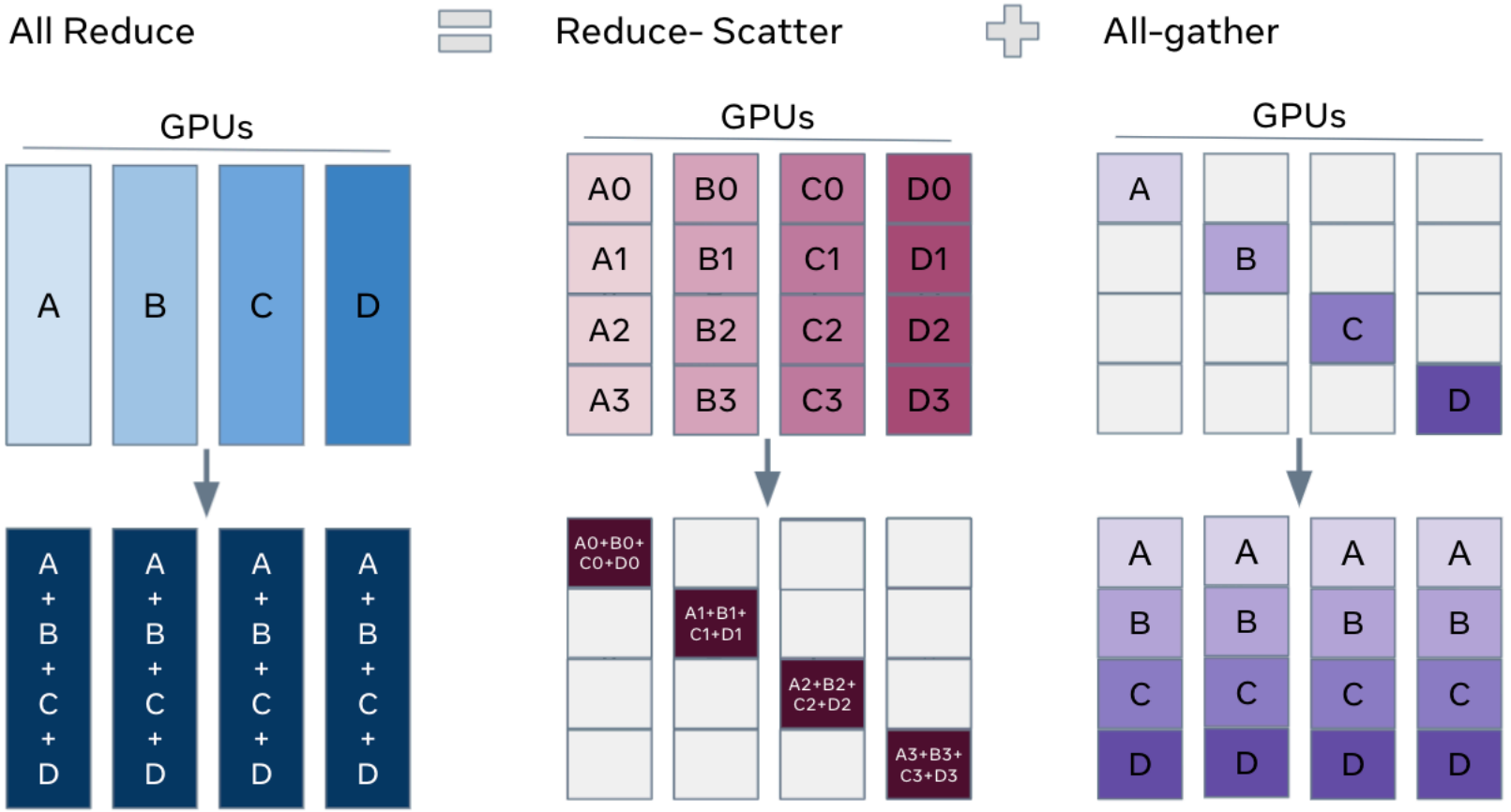
集合式通信方式 (III)：操作分解



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Summary

1. 了解集合式通信的3种不同方式
2. 了解一对多Scatter/Broadcast，多对一Gather/Reduce，多对多的具体方式
3. 了解多对多可以由一对多和多对一的方式组合，all-Reduce = Reduce Scatter + All gather

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