**摘要学习一**

1. 简单描述问题

多商品网络流问题（MCNF）是指以最小成本将一组商品通过一个容量受限的网络进行路由，并与班轮运输网络中的集装箱路由相关。

The multi-commodity network flow problem (MCNF) consists in routing a set of commodities through a capacitated network at minimum cost and is relevant for routing containers in liner shipping networks.

1. 理论模型关键点

由于商品运输时间通常是一个关键因素，文献中对商品运输时间进行了严格限制。

As commodity transit times are often a critical factor, the literature has introduced hard limits on commodity transit times.

1. 结合实际情况

然而，在实际情况下，这些硬限制可能无法提供足够的灵活性，因为即使是微小延迟的路线也会被丢弃。

In practical contexts, however, these hard limits may fail to provide sufficient flexibility since routes with even tiny delays would be discarded.

1. 建模方法

在一家大型班轮运输运营商的激励下，我们研究了一种MCNF泛化方法，其中运输时间限制被建模为软约束，其中使用运输时间的惩罚函数来阻止延误。同样，提前到达的商品可以在成本上获得折扣。

Motivated by a major liner shipping operator, we study an MCNF generalization where transit time restrictions are modeled as soft constraints, in which delays are discouraged using penalty functions of transit time. Similarly, early commodity arrivals can receive a discount in cost.

1. 建模依据

我们推导出了将该模型与其他MCNF变体区分开来的属性，并采用列生成程序来有效地解决它。

We derive properties that distinguish this model from other MCNF variants and adapt a column generation procedure to efficiently solve it.

1. 实验检验

在实际班轮运输实例上进行的大量数值实验表明，与硬运输时间截止日期相比，明确考虑惩罚函数可以显著降低成本。

Extensive numerical experiments conducted on realistic liner shipping instances reveal that the explicit consideration of penalty functions can lead to significant cost reductions compared to hard transit time deadlines.

1. 补充结论

此外，惩罚可用于引导流量朝着更慢或更快的配置方向流动，从而导致运营成本的潜在增加，这会产生我们在不同惩罚函数下量化的权衡。

Moreover, the penalties can be used to steer the flow towards slower or faster configurations, resulting in a potential increase in operational costs, which generates a trade-off that we quantify under varying penalty functions.