Leveraging Deep Learning to Achieve Efficient Resource Allocation with Traffic Evaluation in Datacenter Optical Networks

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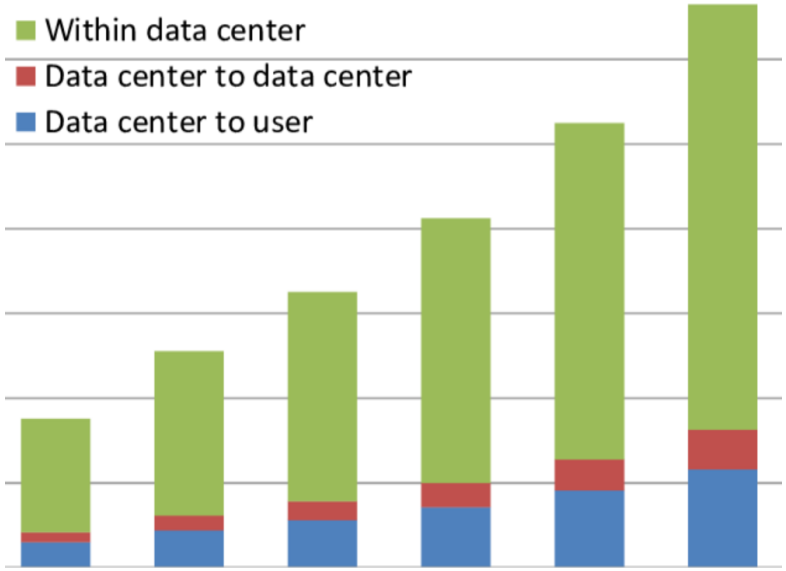
A. Yu, et al. "Leveraging deep learning to achieve efficient resource allocation with traffic evaluation in datacenter optical networks." 2018 Optical Fiber Communications Conference and Exposition (OFC). IEEE, 2018.

Motivation

- **Traffic demand increasing in datacenter networks**
  - Cloud-service, parallel-computing, etc., lead to huge amount of intra datacenter traffic growth.
  - Cisco forecasts 31% increase per year of datacenter traffic by 2021



Datacenter traffic loads is growing

Introduction

- **Traditional intra-datacenter traffic detection methods**
- Support vector machine (SVM)
- Neural networks (NN)
- Decision tree
- NBD

- **Weakness**
- Simple prediction model
- Unguaranteed accuracy due to the change of bandwidth explosion and service diversity
- Unable to detect internal relations for raw data

Deep learning for traffic detection

- **Strengths**
- Discover deep connections in data
- Accurate prediction in complex networks
- Identify and characterize the complex structural characteristics in huge amounts of raw data
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Solution for intra-datacenter networks

- **Deep neural network-based prediction strategy (DNN-PS)**

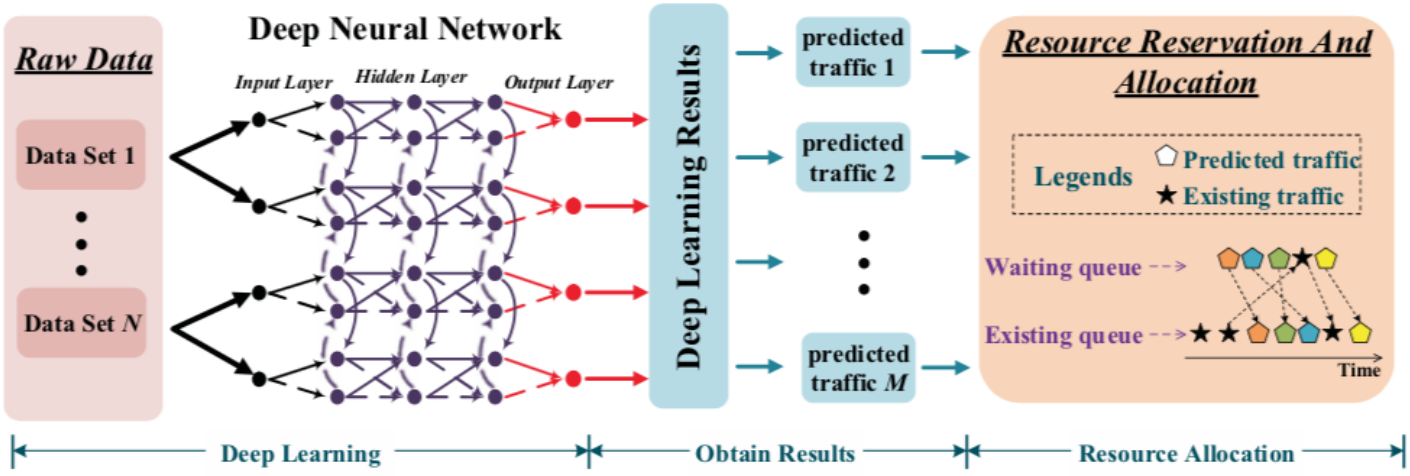


Fig.1 Logic sketch of DNN-PS.

- Build a database containing tens of millions of datacenter traffic information
- Traffic data are collected every 20s from over 200 servers
- Adjusts the weights and bias in DNN during the training process to minimize the objective function.

Solution for intra-datacenter networks

- **Deep learning-based resource allocation algorithm (DL-RA)**
- Use DDN-PS model to predict new traffic data
- Allocate resources for the new arrival traffic
- Use α to evaluate the validity of prediction results in terms of accuracy and resources

$$\alpha=\frac{E\left[T_{pj}^{2}\left(t\cdot t'\right)\right]-\mu_{pj}\left(t\right)\mu_{pj}\left(t'\right)}{\sqrt{D\left[T_{pj}\left(t\right)\right]}\cdot\sqrt{D\left[T_{pj}\left(t'\right)\right]}}\beta+\frac{\sum_{j=1}^{M}\int_{t_0}^{t_N}R_{pj}\left(t\right)dt}{M\int_{t_0}^{t_N}R\left(t\right)dt}\left(1-\beta\right),\quad E\left[T_{pj}^{2}\left(t\cdot t'\right)\right]-\mu_{pj}\left(t\right)\mu_{pj}\left(t'\right)>0$$

Solution for intra-datacenter networks

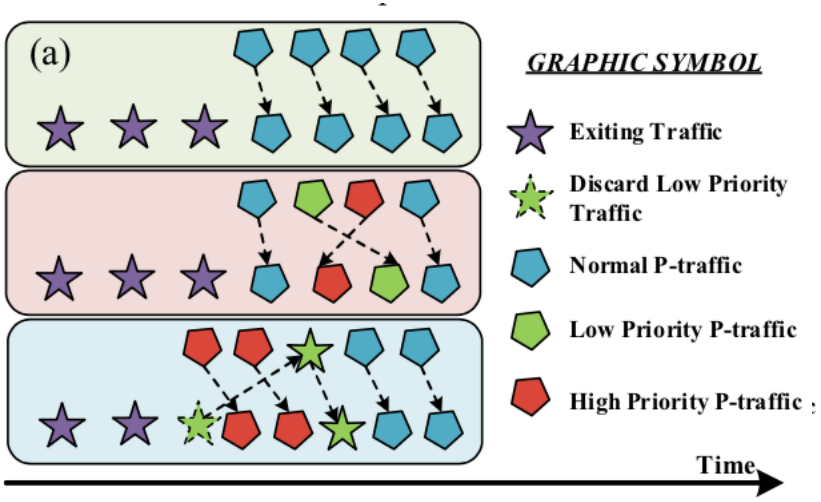
- **Deep learning-based resource allocation algorithm (DL-RA)**
- α considers both accuracy of traffic prediction and global resource utilization

$$\alpha=\frac{E\left[T_{pj}^{2}\left(t\cdot t'\right)\right]-\mu_{pj}\left(t\right)\mu_{pj}\left(t'\right)}{\sqrt{D\left[T_{pj}\left(t\right)\right]}\cdot\sqrt{D\left[T_{pj}\left(t'\right)\right]}}\beta+\frac{\sum_{j=1}^{M}\int_{t_0}^{t_N}R_{pj}\left(t\right)dt}{M\int_{t_0}^{t_N}R\left(t\right)dt}\left(1-\beta\right),\ \ E\left[T_{pj}^{2}\left(t\cdot t'\right)\right]-\mu_{pj}\left(t\right)\mu_{pj}\left(t'\right)>0$$

T_{pi} : arrival time of j^{th} predicted traffic (P-traffic)
u_p : value center of T_p at different amounts of arrival time
t' : predicted arrival time
t : actual arrival time
$R_{pj}(t)$: resources required for the j^{th} arrival predicted traffic at t time
M : total amount of traffic that will arrive during time (t_0 , t_N)
N : arrival time of M_{th} traffic
β : is the adjustable weight between traffic and resource parameters with different user requirements

Solution for intra-datacenter networks

- **Deep learning-based resource allocation algorithm (DL-RA)**
- α considers both accuracy of traffic prediction and global resource utilization



Schematic of traffic queue reordering in DL-RA

Algorithms 1: DL-RA (b)

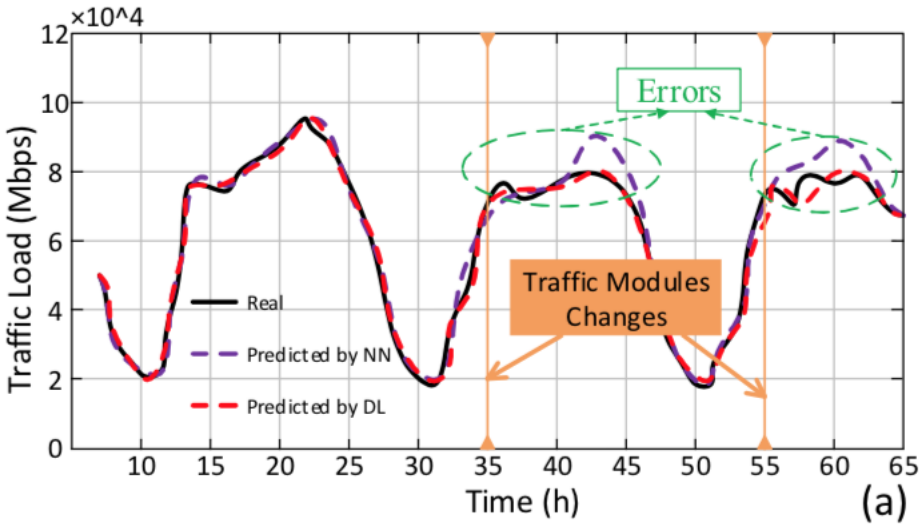
Input: training results T_{pj}; expansion parameter Priority = k

1: **for** each T_{pj}
2: **if** $R_p \le R_t$ **then**
3: **else if** there will be no low priority traffic in queue
4: **else if** k=*low* **then**
5: T will be added to traffic queue
6: **else if** $\alpha >$ *threshold* **then**
7: Allocate resources after discarding
8: **if** $R_p \le R_t$ after resource arrangement **then**
9: Allocate resources after arrangement

The pseudocode of DL-RA algorithm

Simulation results

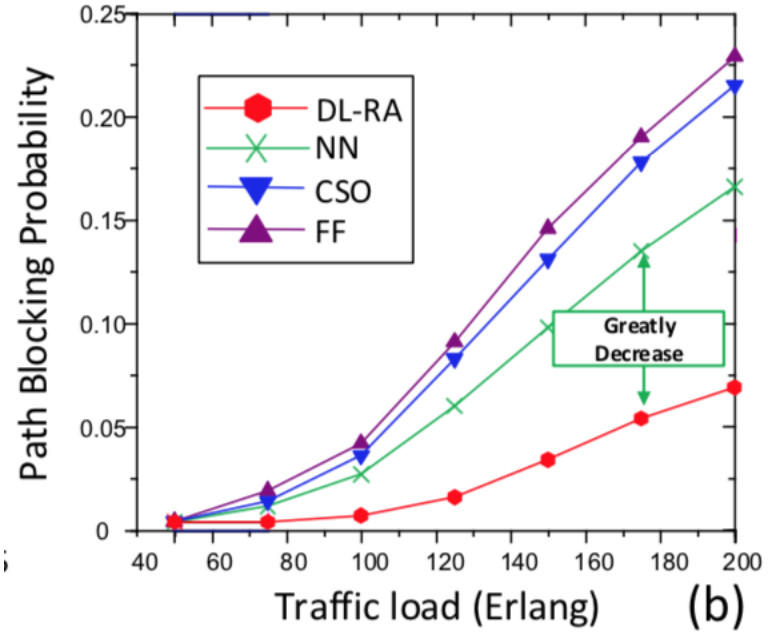
- **Deep learning-based resource allocation algorithm (DL-RA)**



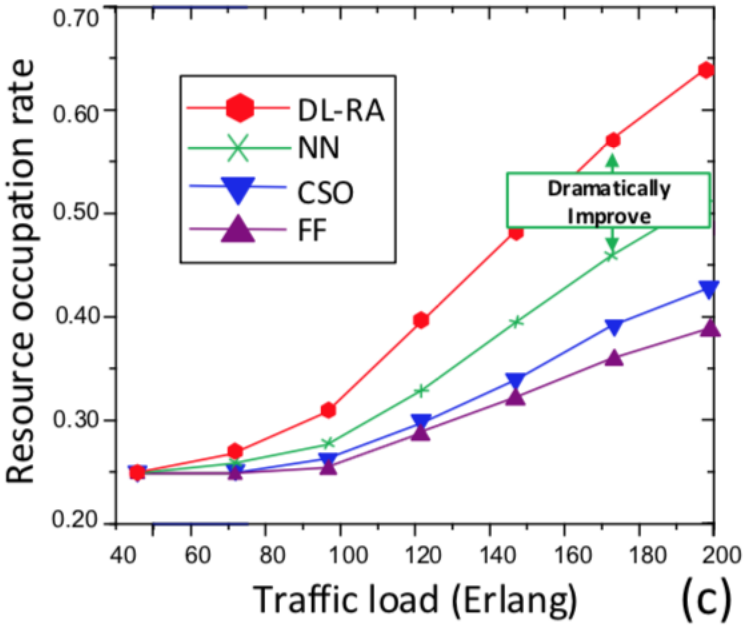
Compare real traffic load, deep learning-based prediction and neural network-based prediction.

Simulation results

- **Deep learning-based resource allocation algorithm (DL-RA)**



path blocking probability among different resource allocation strategies



resource occupation rate among different resource allocation strategies

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