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Thème

Design and implementation of a new optimized coupled BBR

Présenté par:

Mme. BOUFELDJA Manel

Mme. SAFARI Maouadda

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- Dr. Azza Mohammed — Président
- Dr. Zouaoui Chakib — Encadreur
- Dr. Manel Baba-Ahmed — Co-Encadreur
- Dr. Amrane Abdelkader — Examinateur
- Pr. Djebbar Ahmed — Invité

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Abstract

An essential element in MPTCP is the congestion control algorithm (CCA), which plays a vital role in regulating the transmission of data across multiple subflows (SFs). However, there are two primary challenges associated with MPTCP CCAs. Firstly, MPTCP flows need to possess an edge over single-path flows. Secondly, MPTCP flows should exhibit fairness, meaning that SFs sharing a common bottleneck should utilize a bandwidth comparable to that of a single-path flow.

Despite the creation of multiple MPTCP congestion control algorithms (CCAs), none of them have managed to overcome these challenges in all scenarios. In response to this, Google introduced the Bottleneck Bandwidth and Round-trip Time (BBR), a novel CCA designed for single-path TCP. BBR utilizes a network model to achieve exceptional throughput while minimizing delays.

To leverage the high performance of BBR, in this work, we adapted this algorithm to be coupled and operate within MPTCP. To achieve this objective, we utilized the principle of the Linked Increase Algorithm (LIA).

This work has successfully published on GitHub SAFARI and BOUFELDJA [2023] as a public repository. The repository serves as a comprehensive demonstration of the project's code, and resources, making it accessible to a wider audience of developers and researchers.

Keywords: BBR, MPTCP, TCP, LIA, congestion control.

Résumé

Un élément essentiel du MPTCP est l'algorithme de contrôle de la congestion (CCA), qui joue un rôle vital dans la régulation de la transmission des données à travers de multiples sous-flux (SF). Cependant, les CCA du MPTCP posent deux problèmes majeurs. Premièrement, les flux MPTCP doivent posséder un avantage sur les flux à chemin unique. Deuxièmement, les flux MPTCP doivent être équitables, ce qui signifie que les FS partageant un goulot d'étranglement commun doivent utiliser une largeur de bande comparable à celle d'un flux à chemin unique.

Malgré la création de plusieurs algorithmes de contrôle de la congestion (CCA) pour MPTCP, aucun d'entre eux n'a réussi à surmonter ces difficultés dans tous les scénarios, aucun d'entre eux n'a réussi à surmonter ces défis dans tous les scénarios. C'est pourquoi Google a introduit l'algorithme BBR (Bottleneck Bandwidth and Round-trip Time), Google a introduit le Bottleneck Bandwidth and Round-trip Time (BBR), un nouvel ACC conçu pour le TCP à chemin unique. BBR utilise un modèle de réseau pour atteindre un débit exceptionnel tout en minimisant les délais.

Pour bénéficier des hautes performances de BBR, dans ce travail, nous avons adapté cet algorithme pour le coupler et le faire fonctionner dans MPTCP. Afin d'atteindre cet objectif, nous avons utilisé le principe de l'algorithme Linked Increase (LIA).

Ce travail a été publié avec succès sur GitHub SAFARI and BOUFELDJA [2023] en tant que référentiel public. Le référentiel sert de démonstration complète du code et des ressources du projet, le rendant accessible à un large public de développeurs et de chercheurs.

Mots clés: BBR, MPTCP, TCP, LIA, contrôle de congestion

ملخص

عنصر أساسي في MPTCP هو خوارزمية التحكم في الازدحام (CCA) ، والتي تلعب دوراً حيويا في تنظيم نقل البيانات عبر التدفقات الفرعية المتعددة (SFs). ومع ذلك ، هناك نوعان من التحديات الأساسية المرتبطة بخوارزميات التحكم في الازدحام MPTCP. أولاً ، يجب أن تمتلك تدفقات MPTCP ميزة على التدفقات أحادية المسار. ثانياً ، يجب أن تظهر تدفقات MPTCP الإنصاف ، مما يعني أن SFs التي تشترك في عنق زجاجة مشترك يجب أن تستخدم عرض نطاق مشابه لتدفق مسار واحد.

على الرغم من إنشاء خوارزميات متعددة للتحكم في الازدحام MPTCP (CCAs) ، لم ينجح أي منهم في التغلب على هذه التحديات في جميع السيناريوهات. ردا على هذا ، قدمت Google النطاق الترددي Bottleneck Bandwidth and Round-trip Time (BBR) ، وهو CCA جديد مصمم لبرنامج التحكم في الإرسال أحادي المسار. تستخدم BBR نموذج الشبكة لتحقيق إنتاجية استثنائية مع تقليل التأخيرات.

للاستفادة من الأداء العالي لـ BBR ، في هذا العمل ، قمنا بتكييف هذه الخوارزمية لتكون مقترنة وتعمل ضمن MPTCP. لتحقيق هذا الهدف ، استخدمنا مبدأ خوارزمية الزيادة المرتبطة (LIA).

تم نشر هذا العمل بنجاح على GitHub كمستودع عام. يعمل المستودع بمثابة عرض توضيحي شامل لرمز المشروع وموارده ، مما يجعله في متناول جمهور عريض من المطورين والباحثين.

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Acronyms

ISO	International Organization for Standardization
OSI	Open Systems Interconnection
IETF	Internet Engineering Task Force
ASCII	American Standard Code for Information Interchange
IP	Internet Protocol
TCP	Transmission Control Protocol
MPTCP	Multi-path TCP
UDP	User Datagram Protocol
SCTP	Stream Control Transmission Protocol
VLAN	Virtual Local Area Network
WLAN	Wireless Local Area Network
WIFI	Wireless Fidelity
VRF	Virtual Routing and Forwarding
RTT	Round Trip Time
SRTT	Smoothed Round Trip Time
CRTT	Current Round Trip Time
RTTVAR	Round Trip Time Variation
RTO	Retransmission Time Out
DSS	Data Sequence Signal
ISN	Initial sequence number
DSN	Data sequence number
SYN	Synchronize Sequence Number
FIN	Finish Flag
MSL	Maximum Segment Life Time
MSS	Maximum Segment Size
CWND	Congestion Window
RWND	Receive Window
AWND	Advertise Window
Ssthresh	Slow start threshold
SN	Sequence Number
TSN	Transmission Sequence Number
MTU	Maximum transmission unit

ECN	Explicit Congestion Notification
ECE	Explicit Congestion Notification Echo
CWR	Congestion Window Reduce
AIMD	Additive Increase Multiplicative Decease
BBR	Bottleneck Bandwidth and Round-trip propagation time
C-MPBBR	Coupled Multipath BBR
LIA	The Linked increase Algorithm
OLIA	The opportunistic Linked Increase Algorithm
BALIA	Balanced Linked Adaptation
D-OLIA	Dynamic OLIA
D-LIA	Dynamic LIA
WVEGAS	weighted Vegas
ADW-BALIA	Adaptive decrease window for balia
LowRTT	low round trip time
BDP	Bandwidth-Delay-Product
RFC	Request for Comments
PDU	Protocol Data Unit
CCA	Congestion Control Algorithm