Wurf.it: A Network Coding Reliable Multicast Content Streaming Solution - NS-3 Simulations and Implementation

[Extended Abstract for Demo Paper]

Néstor J. Hernández M.[1,2] Jeppe Pihl[2] Janus Heide[2]

Jeppe Krigslund[2] Morten V. Pedersen[2] Péter Vingelmann[2]

[1]Aalborg University - Department of Electronic Systems, [2]Steinwurf ApS
Aalborg, Denmark
[1]nh@es.aau.dk, [2]{nestor|jpihl|janus|krigslund|morten|peter}@steinwurf.com

ABSTRACT

One of the proven benefits of Network Coding (NC) is to achieve the data capacity for multicast networks. However, even though there has been a significant amount of research in this area, potentials demonstrators of these capabilities have not been widely shown or deployed. Thus, in this work we present a set of pre-computed ns-3 simulations to model the behaviour of Wurf.it, a Random Linear Network Coding (RLNC)-based reliable multicast solution for content distribution with cross-platform support. Wurf.it is based on Kodo, a C++11 network coding library that provides the primitive encoding and decoding functionalities and a Simple COded REliability Protocol (SCORE), for erasure correcting purposes in single-hop multicast networks. In this sense, the simulations are shown as part of the modeling required to evaluate the theoretical aspects for the perfomance of Wurf.it. Therefore, our demonstrator consists of stored simulations with ns-3 in a laptop and a Wurf.it implementation within a WiFi network. For the implementation, a video content from a mobile camera is distributed with low delay using SCORE to a set of heterogenous receivers (e.g. different platforms). Use cases of Wurf.it are mild to highly-crowded scenarios, for example: sports stadiums, airports, service-waiting areas and museums.

CCS Concepts

•Networks → Network protocol design; Network performance modeling; Network simulations; Wireless local area networks;

WNS3 '16 June 15-16, 2016, Seattle, WA, USA

DOI: 10.13140/RG.2.1.4565.4643

Keywords

Network Coding, ns-3, Network Protocol, Video, Streaming

1. INTRODUCTION

NC [5] has proven to be a disruptive technology by breaking the paradigm of data routing in current networks since it removes the assumption that data packets are unmodifiable units. Thus, NC moves from the storage-and-forward conception of communication and storage networks to the compute-and-forward paradigm. In NC, packets are treated as algebraic entities that can be operated on creating (new) coded packets, making possible to simplify data delivery. Now, coded packets are *indistingueshable*, e.g. a receiver does not need to receive a *specific* packet in order to later retrieve the original data.

In the NC literature, two basic types can be differentiated: Inter-session and intra-session NC. In the former, packets are combined from two different data flows in the network, while in the latter packets are combined from single flow. In both cases, packets are encoded (combined) in a linear way. Thus, a transmitter generates linear combinations of coded packets and a receiver only needs to collect a linearly independent (l.i.) set from these in order to retrieve the information.

Intra-session RLNC has particularly shown to achieve the max-flow min-cut capacity of multicast packet erasure networks with high probability [8, 7, 6]. The key underlying feature of RLNC that permits to achieve the capacity, is that a single coded packet is more useful to recover from a packet erasure in many receivers than in the uncoded case. This reduces the amount of Forward Error Correction (FEC) required to convey the information. Still, although the benefits of RLNC for multicast sessions have been well studied and addressed, currenty there are few demonstrators regarding its use cases.

Hence, in this work, we present to the research community a set of computed ns-3 [3] simulations and an implementation of Wurf.it [4], a reliable multicast video streamer based in RLNC through SCORE, our in-house reliability protocol and Kodo [9], the underlyting C++11 network coding library. The simulations are intended to show the theoretical aspects required to evaluate performance trends in our implementation. The work is organized as follows: Section II describes the proposed ns-3 simulations. In Section III, we describe the Wurf.it. Conclusion and remarks are drawn in Section IV.

2. NS-3 SIMULATIONS

In this part of the demo, we will introduce ns-3 simulations that model the completion time for decoding a batch network coded packets to a set of heterogenous receives using broadcast RLNC with a basic reliability protocol. The purpose of this part of the demo is to show how a basic descriptive modeling of Wurf.it is made. This part consists of a desktop computer showing ns-3 simulations of the distribution broadcast RLNC completion time through proper scaling of the number of transmissions required to decode the data. The number of transmissions include attemps to overcome the packet erasures from the network. To achieve this, we use a set of ns-3 examples built with Kodo, that are available in [1] with a tutorial in [2]. During the demo, the examples are tailored to show continuous output of these simulations with network parameters through local data loading to show the changes on the mean completion-time in the simulations.

3. WURF.IT

The Wurf.it solution is shown in Fig. 1 where we present: (a) a generic architecture of the solution and (b) how redudant packets are made using RLNC as a FEC scheme. Wurf.it comprises of a server distributing incoming content through a network in a broadcast fashion to a set of heterogeneous receivers that run a user-space client application. The receivers acknowledge with unicast messages when they get their data. To recover from erasures, a systematic RLNC with $GF(2^8)$ scheme is considered where the application messages are divided into generations of ten packets. For each generation, the original packets are sent first and later redundant coded packets are sent to recover from losses between the access point and the receivers. Following, each generation is decoded by collecting enough l.i. coded packets. We will present a demo of Wurf.it where we stream video from a mobile device camera acting as the server, through a WiFi access point in broadcast mode to 5 heterogenous receivers in its coverage area.

4. CONCLUSIONS

Due to the benefits brought by network coding to broadcast networks and the lack of application demonstrators widely deployed in this area, we present a set of ns-3 desktop simulations and an implementation to model Wurf.it, a service from data streaming in multicast networks with heterogenous receivers. The real-time simulations in this work for modeling the have been tailored from a set of examples using Kodo with the ns-3 simulator.

5. ACKNOWLEDGMENTS

This research has been partially financed by the CROSSFIRE MITN Marie Curie project (317126) from the European Comission FP7 framework, the Green Mobile Cloud project (Grant No. DFF - 0602 - 01372B) and the TuneSCode project (Grant No. DFF - 1335-00125) both granted by the Danish Council for Independent Research.

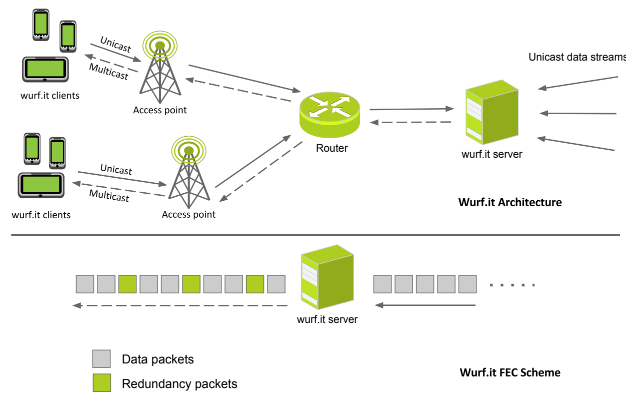

Figure 1: Wurf.it Solution: (a) Architecture. (b) FEC Scheme

6. ADDITIONAL AUTHORS

Additional authors are: Daniel E. Lucani from Aalborg University and Frank H.P. Fitzek from Technische Universität Dresden. Email: `del@es.aau.dk, frank.fitzek@tu-dresden.de`.

7. REFERENCES

[1] Kodo examples for the ns-3 simulator git repository. https://github.com/steinwurf/kodo-ns3-examples. Accessed: 2016-06-23.

[2] Kodo-ns3-examples documentation read-the-docs tutorial. http://kodo-ns3-examples.readthedocs.org/en/latest/. Accessed: 2016-06-23.

[3] ns-3 website. https://www.nsnam.org. Accessed: 2016-06-23.

[4] Wurf.it: A media streaming service based on rlnc. http://steinwurf.com/technology.html. Accessed: 2016-06-23.

[5] R. Ahlswede, N. Cai, S.-Y. Li, and R. W. Yeung. Network information flow. *Information Theory, IEEE Transactions on*, 46(4):1204–1216, 2000.

[6] A. Eryilmaz, A. Ozdaglar, M. Médard, and E. Ahmed. On the delay and throughput gains of coding in unreliable networks. *Information Theory, IEEE Transactions on*, 54(12):5511–5524, 2008.

[7] T. Ho, M. Médard, R. Koetter, D. R. Karger, M. Effros, J. Shi, and B. Leong. A random linear network coding approach to multicast. *Information Theory, IEEE Transactions on*, 52(10):4413–4430, 2006.

[8] R. Koetter and M. Médard. An algebraic approach to network coding. *IEEE/ACM Trans. Netw.*, 11(5):782–795, 2003.

[9] M. Pedersen, J. Heide, and F. Fitzek. Kodo: An open and research oriented network coding library. In *Networking 2011 Workshops*, volume 6827 of *Lecture Notes in Computer Science*, pages 145–152. Valencia, Spain, 2011.