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360 Degree Video Over ICN Demo

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Familiar yourself with information-centric networking

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- Slides and papers from Professor Dirk Kutscher and other researchers
  - https://gitlab.com/dkutscher/pub/-/blob/main/kutscher-icn-helsinki.pdf
  - https://leeexplore.ieee.org/document/6231276
  - https://www.cs.princeton.edu/courses/archive/fall18/cos561/papers/NDN18.pdf

- Other materials
  - https://people.eecs.berkeley.edu/~alig/papers/information-centric-networking-seeing-the-forest-for-the-trees.pdf
  - https://www.cse.wustl.edu/~jain/cse570-19/ftp/icn/Index.html
  - https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=521f17e13cc46d29a3aaac7ea829bd2a91fd9ff9
  - https://leeexplore.ieee.org/document/6563278

Possible solutions

- psync with high latency
- dash over NDN
- other streaming system implemented over NDN
- miniNDN could be an option for the starting point
- Goal: a preliminary demo system transmitting 360 video over NDN

Streaming related

- Concept
  - https://www.huaweicloud.com/intl/en-us/product/cvcs/HybridVideo_02.html
- Papers
  - https://named-data.net/wp-content/uploads/2015/05/ndn-0031-1-ndnlive-ndntube.pdf
  - https://dl.acm.org/doi/abs/10.1145/3581791.3597294
  - https://dl.acm.org/doi/abs/10.1145/3581791.3597295
  - https://leeexplore.ieee.org/document/9537928
  - https://arxiv.org/abs/2207.07394

NDN project

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- Papers
  - https://dl.acm.org/doi/pdf/10.1145/2656877.2656887
  - https://conferences.sigcomm.org/co-next/2009/papers/Jacobson.pdf
  - https://named-data.net/techreport/TR001ndn-proj.pdf

- Code repo
  - https://named-data.net
  - https://GitHub.com/named-data

- Core
  - Ndn-cxx
    - https://GitHub.com/named-data/ndn-cxx
  - NFD
    - https://GitHub.com/named-data/NFD
  - NLSR
    - https://GitHub.com/named-data/NLSR
- Other useful
  - Ndntools
    - https://GitHub.com/named-data/ndn-tools
  - Mini-ndn
    - https://GitHub.com/named-data/mini-ndn
  - ndn-traffic-generator
    - https://GitHub.com/named-data/ndn-traffic-generator

My environment

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- Local
  - Windows 11 home + wsl2
    - Details:

      windows subsystem Linux with distro ubuntu,

      Kernel:5.15.90.1-microsoft-standard-WSL2, rebuilt with media driver support

      (https://GitHub.com/microsoft/WSL2-Linux-Kernel))
  - Virtual machine: VirtualBox on windows with ubuntu22.04, 20.04, 18.04
  - Docker :docker desktop on windows with wsl2 Integration

- Remote
  - Cloud computing : aliyun (ECS computing *3, GPU computing * 1)
    - https://www.alibabacloud.com/

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Minindn

- **Some warnings are fine:**
  - Tested on local virtual machine docker container
- Docker solution on my host failed
  - No modules

Ndn-tools

- We can transfer files with putchunks/getchunks

Explore more with minindn experiments(default examples or write your own)

Work from cisco

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- The robust paper
  - robust + (webrtc + icn) -> hicn
  - https://GitHub.com/FDio/hicn
  - **https://Ieeexplore.ieee.org/document/10178023**

- Familiar yourself with webrtc & peer.js
  - **https://ieeexplore.ieee.org/document/9153228**
  - https://webrtc.org/
  - https://peerjs.com/
  - https://YouTube.com/playlist?list=PLCJBf3eedefzXOQihAamh17r4Sm7gavhX&si=zg4IhXh_CA8IP-kj
  - https://datatracker.ietf.org/meeting/100/materials/slides-100-edu-sessm-webrtc-tutorial-part-1-00.pdf
  - Quick start as a newbie:
    - https://youtu.be/WmR9IMUD_CY?si=ZI-Uq9WHv1balTk9
    - https://youtu.be/DvlyzDZDEq4?si=27HS7ilvVL7yGTe6
    - https://www.YouTube.com/live/1cYKoSe3MN4?si=1sqtI0WqvLKP9AAv

Work from cisco (cont.)

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Codes are not available

according to Luca Muscariello (lumuscar) <lumuscar@cisco.com> at cisco

> “If you are looking into WebRTC for real-time applications, the code is only partially available In open-source. We intend to open-source also the entirety of that code but the process is long and lengthy
>
> and I cannot guarantee any date for that”

NDNRTC

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- Other streaming technique with ICN

  https://www.sciencedirect.com/science/article/abs/pii/S1389128617302414

  - Outdated

- Ndn-rtc
  - https://dl.acm.org/doi/10.1145/2810156.2810176
  - https://GitHub.com/remap/ndnrtc/

  - Ndnrtc headless client
    https://GitHub.com/remap/ndnrtc/blob/master/cpp/client/README.md

NDNRTC (cont.)

➢ Environment set up

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- VirtualBox
  - high overhead while fetching webrtc code, no enough storage on disk
- aliCloud ecs :
  - ➢ set up the proxy due to the GFW:
  - ➢ use the clash project
    - https://GitHub.com/Dreamacro/clash
    - https://dreamacro.GitHub.io/clash/
    - https://GitHub.com/Fndroid/clash_for_windows_pkg
    - https://GitHub.com/wanhebin/clash-for-Linux
  - ➢ add “185.199.108.133 raw.githubusercontent.com” to /etc/hosts

BE CAREFUL : most Issues caused by complicated network, win, ubuntu wsl, vm .etc

NDNRTC (cont.)

➢ Environment set up (cont.)

- Issues
  - ➢ different c++ standard, some outdated library, python link. ubuntu distro version .etc
  - ➢ weird conflicts
  - ➢ some behaviors I encountered are published on GitHub Issue, stackoverflow or other platform, but no-one answered
  - ➢ modify the code (Includes, Makefile, CMakeList, comment something to move on)

- Modified codes
  - ➢ Sorry my modified version on the alibabaCloud server was deleted accidentally
  - ➢ You can check out my docker solution

NDNRTC (cont.)

➢ Environment set up (cont.)

- Docker
  - ➢ docker on alibabaCloud
    - Just crashed
  - ➢ docker on host machine
    - turns out there're Issues in the Dockerfile
    - to docker hub for public

- Solution to the docker approach
  - ➢ Modified Dockerfile
    - check on my docker hub
  - ➢ to Use the docker image I built after modification (without client)
    - docker pull nemo1111/ndnrtc
  - ➢ from peter:
    - https://GitHub.com/peetonn/ndn-docker
    - docker pull peetonn/ndnrtc

NDNRTC (cont.)

➢ Environment set up (cont.)

- Headless client
  - ➢ Official method failed
  - ➢ Just use the binary from peter's docker image
  - ➢ Or you can try this simplified and modified from configure.ac and Makefile.am

```
g++ -std=c++11 -Wall -O2 -o ndnrtc-client1 client/src/*.cpp -static -lconfig++ -lndn-cpp -lboost_system
 -lboost_chrono -lboost_thread -lndnrtc -pthread  -ldl -lX11 -lXdamage -lXrender -lXext -lXfixes -
lXcomposite -lssl -lcrypto
```

- Ndncon
  - ➢ https://GitHub.com/remap/ndncon
  - ➢ Could be useful
  - ➢ But it's running on MacOS

- Just FYI
  - ➢ It cost 380GB to build NDNRTC lib, cause re-fetching WEBRTC over and over again In all kinds of approaches
    - (according to proxy service network dashboard)

NDNRTC (cont.)

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➢ Results

- Headless client works well
  - ➢ Communication between two docker containers using peter's image on the host
  - ➢ **Enable x server and camera in case further development if you would like**

```
docker run --rm -ti --name ndnrtc    --network ndnrtc-subnet   -v /dev/video0:/dev/video0   -v /tmp/.X11-
unix:/tmp/.X11-unix       -v /mnt/wslg:/mnt/wslg     -v pwd)/container-tmp:/tmp         -e DISPLAY
-e WAYLAND_DISPLAY      -e XDG_RUNTIME_DIR       -e PULSE_SERVER     nemo1111/ndnrtc /bin/bash
```

- Not suitable for development based on ndnrtc
  - From Teng Liang <philoliang2011@gmail.com> :

> "Right, NDN-RTC is quite outdated, and there were some unfixed bugs before it was abandoned.
>
> Other than NDN-RTC, I don't know any other open-sourced projects designing or Implementing WebRTC-style framework In NDN."

Other attempts

- Inspiration from other researchers
  - From Luca Muscariello (lumuscar) <lumuscar@cisco.com> at Cisco

> "If you are interested in video streaming, I would be thinking about ABR video and not WebRTC.
>
> Most of the code about ABR video Is already published and available in the open-source project FDio. It works for MPEG-DASH and HLS"

  - From Teng Liang <philoliang2011@gmail.com>

> "One thing Beichuan and I have been working on is NDNizing existing applications, which is to translate some key modules in existing framework/api making it NDN-capable. Have published some papers on this direction.
>
> Regarding WebRTC, one way is that we can find some existing open-source and easy-to-modify frameworks. Starting from there we can analyze and design which part to be NDNized. Given the maturity of NDN libraries, C++, Python, and JS/TS are recommended. I'd like to help If you need more discussion."

Other attempts (cont.)

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- Paper
  - https://dl.acm.org/doi/pdf/10.1145/3267955.3267969
  - NDNlize exist application level protocol (icmp xmpp as eg)
  - from scratch(like ndnrtc)
  - proxy between tcp/Ip and ndn(like hicn I think)
  - proxy between app-p and ndn(chosen)
  - off the grid(not by address)
  - proxy(hybrid--selector)

Other attempts (cont.)

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- LL-HLS [need to be ndnlized]
  - https://dl.acm.org/doi/pdf/10.1145/3517212.3559488
  - (found the ietf draft)
  - hls-adaptive bitrate streaming(resemble dash as apple claims)
  - in my words, well-prepared before respond the Interest
  - 3/5 extensions(3 net communication, 2 client mod)
  - server: gpac not srs(support many protocol)
  - client:shaka player
  - but didn't get the code

ICN-360

- https://GitHub.com/ICN2020/icn-360/
- producer just set the source put the data on face, let nfd handle the rest
- namespace: meta and image
- single normal camera won't work

- Familiar yourself with three.js
  - https://threejs.org/
  - **NOTE: threeJS usage In this project were depreciated**

ICN-360 (cont.)

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- Environment set up
  - Modification:
    - Makefile: rules, opencv, compiler
    - fix syntax: const in vector, public/private
    - opencv updated (some sols in stackoverflow)
    - ndn-cxx updated: (introduced 'span')
      - release note, api and src from the doc
  - Codes :
    - See codes in my docker image
- Results (example video see … or YouTube, URL didn't work, audio didn't work)
  - 720p source video(downloaded from YouTube with original resolution 4k)
  - laptop host -to- alicloud(forward to local browser):***ok***, doesn't recover tiles In time, sometime high lost,
  - laptop host -to- laptop host : ***ok***, same as last item
  - alicloud -to- laptop host: ***nope..*** something wrong In nfd process
  - alicloud -to- alicloud: ***nope..*** something wrong In nfd process

Video stitcher

- https://GitHub.com/ultravideo/video-stitcher/
- https://ieeexplore.ieee.org/document/8965900
- Stitch normal video to 360 degree video (producer)
- **Try to integrate this with icn-360 to achieve real time 360 video transmission**

- Environment set up
  - **opencv Issue:**
    - icn360 needs opencv3, built manually,
    - stitcher needs modified-opencv
    - (need to modify some code if in latest opencv4)
  - **solution:**
    - skip to built opencv3 and Icn360 first
    - turns out customed opencv is based onopencv3.4

Video stitcher (cont.)

➢ Environment set up

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- cuda issue:
  - ➢ My host failed to set this up
  - ➢ Had solved the cuda toolkit and Nvidia driver in wsl2
- solution:
  - ➢ VirtualBox doesn't support PCI:
    - virtual machine approach failed
  - ➢ compose a Dockerfile:
    - writing while building Images
    - docker solution failed due to wasting lots of time
  - ➢ Find out they use cuda9 In the GitHub issue session
    - no cuda Image for cuda9

Video stitcher (cont.)

➢ Environment set up – cuda Issue solution

- alibabaCloud GPU computing
  - ➢ install the driver and cuda manually
  - ➢ (can be installed automatically but we need cuda9)
  - ➢ downgrade the ubuntu version to 18.04
  - ➢ NOTE: g++6 (must be version6) for this, but greater than g++9 for ndncxx

  - ➢ compiled successfully
    - Install the Nvidia driver: all solution are non-free, cheat to use a free one
    - Paid version driver doesn't match up with the toolkit
    - NOTE: due to the uniqueness of server(A1 graphic card): cuda and driver won't match In this case
- You can try other GPU cloud computing ex: AWS

Video stitcher (cont.)

➢ Environment set up

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- Camera issues

➢ since provider now is on real-server side, we need to forward the usb camera on host to the ssh server

➢ Use usbip & usbipd

- https://usbip.sourceforge.net/
- https://GitHub.com/dorssel/usbipd-win
- Wsl2-win11 set up successfully
- alibabaCloud-wsl2 **failed**
- DO NOT RECOMMEND

➢ try to use phone camera as remote webcam

- success on host but high latency(not useful)

Video stitcher (cont.)

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- Results
  - **Fail to run the stitcher project**
  - other video stitcher projects:
    - no other more useful sources than this
    - someone(GitHub, reddit, blog .etc) suggest to use professional paid software or 360 camera
      - Not what we desired
  - **What Haven't been tried:**
    - Back up the whole env and all files on my host to reboot the laptop to ubuntu
    - Dual boot the laptop to win + Linux
  - **What could be tried:**

(I have tried all the method I can think of to set up these but every time everything crashed when It is about to reach 90% to 100%)

- *It has been so many years since these two projects were released*
- *we'll waste lots of time in fixing the **compatibility issue** not to mention improving latency In net layer*
- It seems like we need at least two real machine for this which have Nvidia GeForce and Is able to run old ubuntu18.04 with some usb port and real webcams

Conclusion

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- To build the demo:
  - As said on the previous slides:
    - Considerable time has been expended addressing the compatibility issue, and unless we change our approach, we can anticipate further time wastage.
  - Ndnlize existing real-time framework like WebRTC(Remap), LL- HLS .etc from scratch
    - Developing this project based on existing ones within a short period of time would be impossible

- My docker images
  - I packed the environment and codes on my host to a docker image
  - https://hub.docker.com/u/nemo1111

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THANK YOU!