

Recommendations for Designing Hybrid Conferences

Vaibhav Bajpai
CISPA Helmholtz Center for
Information Security
bajpai@cispa.de

Oliver Hohlfeld
Brandenburg University of
Technology (BTU)
oliver.hohlfeld@b-tu.de

Jon Crowcroft
University of Cambridge
jon.crowcroft@cl.cam.ac.uk

Srinivasan Keshav
University of Cambridge
sk818@cam.ac.uk

Henning Schulzrinne
Columbia University
hgs@cs.columbia.edu

Jörg Ott
Technical University of Munich
ott@in.tum.de

Simone Ferlin
Ericsson AB
simone.ferlin-reiter@ericsson.com

Georg Carle
Technical University of Munich
carle@in.tum.de

Andrew Hines
University College Dublin
andrew.hines@ucd.ie

Alexander Raake
Technische Universität Ilmenau
alexander.raake@tu-ilmenau.de

This article is an editorial note submitted to CCR. It has NOT been peer reviewed.
The authors take full responsibility for this article's technical content. Comments can be posted through CCR Online.

ABSTRACT

During the COVID-19 pandemic, many smaller conferences have moved entirely online and larger ones are being held as hybrid events. Even beyond the pandemic, hybrid events reduce the carbon footprint of conference travel and makes events more accessible to parts of the research community that have difficulty traveling long distances, while preserving most advantages of in-person gatherings.

While we have developed a solid understanding of how to design virtual events over the last two years, we are still learning how to properly run hybrid events. We present guidelines and considerations—spanning technology, organization and social factors—for organizing successful hybrid conferences.

This paper summarizes and extends the discussions held at the Dagstuhl seminar on “Climate Friendly Internet Research” held in July 2021.

CCS CONCEPTS

• **Social and professional topics;**

KEYWORDS

Hybrid conferences, workshops, meetings, teaching

1 INTRODUCTION

Hybrid conferences combine elements of both in-person and virtual conferences. A fraction of attendees gathers in a single physical location, while others interact synchronously from afar¹. This approach promises to provide some of the benefits of attending a

conference to remote attendees, while making events more accessible and reducing their carbon footprint.

Hybrid conferences are not new. For many years, some conferences have offered passive remote participation options such as video live streams of keynotes. Others, such as the Internet Engineering Task Force (IETF) standardisation community, for example, have experimented with remote active participation of speakers and even session chairs, going back to “The First IETF Internet Audiocast” in 1992 [3], during which a session presentation was delivered via an audio stream over the internet. This initial experiment evolved to the hybrid and fully virtual meetings the IETF runs professionally today.

In the following, we use the term “conference” for a broad set of interactive gatherings, from small, closed-participation project meetings and thesis defenses to workshops and traditional conferences sponsored by technical societies. While such hybrid conferences share characteristics and challenges with teaching hybrid or “HyFlex” classes², they often raise unique issues, such as financial implications and development of a research community. We use the term “in-person” and “physical” interchangeably, referring to the traditional mode of attendance, while “online”, “remote” and “virtual” all designate those aspects that take place remotely, mediated by the internet.

Organizing the remote portion of hybrid conferences can benefit from the recent ACM report on virtual conferences [4] and thus these discussions will not be reprised here. However, not all the changes to conference organization and structure proposed in the ACM report that make virtual conferences more productive and

¹We do not consider making video recordings of talks online to be a hybrid conference since this does not allow interaction.

²The term HyFlex has been used for classes that allow students to choose between synchronous in-class, synchronous remote and asynchronous participation, possibly switching between modes during the semester (<https://www.buffalo.edu/edc/AcademicPreparedness/HyflexModel.html>).

enjoyable for remote attendees will work for hybrid events, and additional issues arise. The goal of this paper, therefore, is to lay out a terminology and guidelines for organizing successful hybrid conferences.

We start with motivating the need for hybrid conferences (Section 2), followed by terminology (Section 3) and guidelines on choosing a hybrid conference mode (Section 4). Section 5 has broad recommendations on the technical, logistical, structural, and operational aspects of hybrid conferences. More specific recommendations are presented in Section 6. We present challenges and opportunities in Section 7 and conclude in Section 8.

2 WHY HYBRID CONFERENCES?

Hybrid conferences are having their moment primarily due to the prolonged and open-ended transition period from the COVID-19 pandemic, where conference organizers want to be able to offer in-person experiences, yet many attendees cannot attend due to travel restrictions, face significant hurdles to attendance such as quarantine on arrival or return, or feel uncomfortable traveling due to health concerns.

Hybrid conference also address rising concerns relating to the carbon footprint of air travel [9]. For many researchers, traveling to conferences may well be a significant, or even largest, contributor to their annual carbon footprint³. Thus, instead of foregoing conference travel altogether, a researcher may choose to attend events in their own region in person, particularly if low-carbon options such as train travel are available, while remotely attending more distant events or events that benefit less from in-person interactions.

Hybrid conferences can also promote inclusiveness of members of the community, e.g., those that are not able to attend due to family obligations, budget restrictions, difficulties obtaining a visa or disability. This is particularly valuable to both diversify the audience and to put together diverse panels of more senior members of the research community who might not be able or willing to spend three days traveling to speak for ten minutes on a panel.

Section 7.2 has additional reasons why we believe hybrid conferences offer benefits compared to purely in-person or purely virtual conferences.

3 TERMINOLOGY

We propose the following taxonomy that will be used in the rest of the paper. Here, *local* means that the activity takes place on-site at the conference venue, typically a meeting room, university class room, or hotel meeting venue. We refer to the attendees participating via the internet as *remote* participants.

Passive hybrid: Passive hybrid conferences allow only local participants to contribute interactively. Remote participants view streaming video of talks, demos, and panels. Material such as research presentations may be recorded ahead of time and played back to allow live audience discussion, or may be live, sometimes alternating within a single session. In this mode, informal and interactive parts of the program, such as panels, are purely local. Remote participants can

only use non-interactive channels to ask questions, e.g., via an email list or Slack.

Semi-passive hybrid: Unlike a passive hybrid, a semi-passive hybrid conference has both local and remote participants. Remote participants interact by asking questions, e.g., via the chat function in a videoconferencing tool, but cannot present or be panelists. Presentations may be either live or recorded.

True hybrid: In a true hybrid conference, presenters, panelists and audience members can be either local or remote.

Distributed hybrid: In a distributed hybrid event, the organizers set up regional in-person clusters, or *hubs*, with a shared program and viewing parties for presentations given elsewhere. Hubs may feature some in-person speakers, or may only allow local interactions.

4 CHOOSING A HYBRID MODE

From this taxonomy, it is clear that hybrid conferences occupy a spectrum. Events requiring continuous close interactions, such as workshops, project meetings, standardization bodies, and similar groups will likely only work well in a true hybrid mode. Events that incorporate both small working group meetings or workshops with large-scale plenaries have different levels of interactivity and may require combining multiple hybrid modes.

Event organizers have to decide early on the style of hybrid event that meets the needs of the local and remote communities, and whether the organizer can stage the more elaborate production required for a true hybrid event. Generally, operational complexity increases from passive to semi-passive to true hybrid and distributed hybrid conferences. A true hybrid conference is likely to require significant on-site audio-video expertise and non-standard video production equipment, as described in Section 5.1. Conversely, the experience of the remote attendees improves as interactivity is added.

Given the relative novelty of hybrid events, evolving technology and changing expectations, conference organizers should systematically gather and evaluate feedback from both in-person and remote attendees, so that events that follow or are part of the same community (e.g., SIG) can learn from earlier experiences. Thus, even experiments in tools and organization that turn out to be unsuccessful are encouraged, particularly if the outcome of the experiment can be disseminated to others [5].

In many cases, a strong motivation for holding a hybrid conference is that speakers or panelists are only able to participate remotely, so the mode of operation may be dictated by those speakers, not necessarily participants in the audience.

Many hybrid conferences have chosen to play pre-recorded presentations followed by live Q&A, as this seems to offer a good trade-off between approximating a live event and reducing the chance for technical glitches and dealing with presentations that exceed their time allocation. While practical, the reception of this model appears to have been mixed. Local participants may not necessarily want to watch video presentations when speakers are present. Thus, we suspect that most hybrid conferences will prefer to have most of their speakers give live presentations, but may want

³For example, the average carbon footprint per person living in the United States is 16 tons [11]; a round trip from New York to Japan adds 3.6 tons [8].

to offer speakers the option to record their talk for the conference record or to deal with last-minute travel difficulties.

Distributed hybrid conferences may reduce the carbon footprint compared to a single conference, as most attendees will have to travel much shorter distances. On the other hand, running multi-site conferences has the risk of ending up with a multi-conference experience. As such, local hubs still have the advantage of socialising with people at a smaller scale at a much more personal level due to the localised nature of languages as well. However, during SIGCOMM 2021, only two watch parties appear to have been organized, both in the United States.

In many cases, technical capabilities at the venue chosen, along with staffing, will determine which hybrid mode can be implemented successfully. University and hotel audio-visual (AV) staff may not be familiar with the needs of remote participants, so early planning and, importantly, testing are crucial to ensure success. Indeed, hybrid conferences may need a new role of production director to manage the live broadcast aspects of hybrid events.

5 GENERAL RECOMMENDATIONS

5.1 Technical Aspects

Today's video conferencing tools are dramatically better than the ones in use in 2020. Yet they still are difficult to use for larger events. Conference organizers are likely face some technical difficulties, even if only of the "you're muted" variety. Organizers of hybrid conferences, other than passive ones, additionally need to consider the interaction of remote and local participants. In the remainder of this subsection, we present our recommendations for technical aspects of hybrid conferences in the areas of audio, video, and floor control. Compared to traditional live-only conferences, use of conferencing tools will likely provide a high-quality recording of the event without additional effort.

5.1.1 Audio. Successful conferences depend on providing high-quality audio to both on-site and remote participants. Inadequate pickup of local participants, echo, latency, network impairments, and lack of spatial placement may make listening tiring or impossible [10]. Unfortunately, achieving good audio quality, especially for remote participants, is still a significant technological challenge. Hybrid scenarios introduce added technological complexity, new points of failure, and listening environments with different room acoustics that are out of the sound engineer's control. On the other hand, the real-time speech-to-text capabilities of video conferencing tools and, in the future, automated translation into other languages may offer advantages both to remote participants as well as to local participants who have difficulty hearing or understanding the conference language.

Several approaches can help achieve good audio quality in hybrid settings. For passive conferences, connecting "house audio" to a laptop streaming the conference to remote viewers will suffice, but audio levels need to be tested well in advance.

For all types of hybrid events, audience questions tend to pose particular challenges. Without good microphone options for the audience, speakers may need to be reminded to repeat questions.

For conferences where the on-site participants can fit around a large conference table, a high-end conference microphone or smart

microphone array is relatively easy to arrange and may offer the best sound quality.

Larger events such as those held in hotel ballrooms make it surprisingly easier to achieve good audience audio since local attendees will either have to walk up to an aisle microphone or be handed a wireless handheld microphone by a runner even without remote participation.

For larger conferences, local participants can use their own laptop to join the conference online, but with loudspeakers muted, essentially converting a laptop into a microphone. However, properly combining a microphone array or laptop audio with a podium speaker's microphone might require sophisticated audio processing for mixing the different audio sources.

Some events have experimented with throwable microphones – wireless microphones placed in a foam ball that are meant to be thrown among audience members.

5.1.2 Video. Presentations can be easily distributed if the in-person presenter also hosts the videoconferencing application. Capturing participants on video requires more thought, as being able to recognize audience members or see facial expressions engages remote participants. For very small hybrid conferences, smart cameras that automatically focus on the person currently speaking, or even a webcam, may be sufficient. For mid-size events, participants can provide a video feed from their own laptop by running the videoconferencing application. For larger events, capturing more than just the general crowd view of the in-person attendees will likely require a camera operator and a remote-control pan-tilt-zoom (PTZ) camera.

A fully professional-quality production calls for a video mixer fed by multiple PTZ cameras and may be well advised to hire a video production crew ("videographer").

To help integrate the remote participants into the local event, it helps to have two large screens in the venue, one showing the remote audience and one the presentation.

5.1.3 Floor Control and Q&A. Floor control, i.e., managing questions or discussion contributions, is much more complicated in hybrid events than in either purely in-person or purely virtual ones. Generally, even for small events, a moderator or session chair will need to manage who speaks next, making sure that both local and remote participants are recognized. Nevertheless, free-flowing discussions are likely to be challenging since local attendees likely lack sufficient visual cues to see if a remote participant wants to speak up. For an on-site moderator, it will likely be difficult to track the order of hand raising. Better tools that put both remote and local participants on an equal footing would be helpful.

Using technology to assist in running hybrid events offers promising solutions, however this technology requires operation and monitoring and can divert attention from the event. Dealing with technology issues regularly falls to session chairs and moderators. Live broadcast and stage production events have long recognised the need to split responsibilities between content and technical coordination. This division of labour can be considered even for small events – similar to having a moderator and minute taker at a meeting so the chair can focus on managing the meeting content and progress.

For virtual conferences, text chat has proven itself to be a valuable way to manage audience questions. It allows both written and verbal answers, making it easier to answer more questions even if time does not permit answering all questions verbally. Text chat can be supported by some combination of chat tools built into most videoconferencing applications or stand-alone, channel-based tools such as Slack or Discord. Text questions also encourage more people to ask questions without having to stand up and speak in public – and it discourages mini-lectures masquerading as questions from the floor, while allowing the moderator or session chair to pick questions of general interest. It may well be worth considering using this mode even for local attendees if they can be assumed to have access to a laptop or smartphone.

Text chat may yield discussion threads in parallel to the audio stream and may thus require the participants to pay attention to, and possibly interact with, multiple information feeds at the same time, which increases their cognitive load. It appears useful to define where such text discussion should take place, in case of multiple options, e.g., a chat channel within the conference tool and a conference-specific Slack channel.

While smaller in-person-only events could get by with having the speaker manage questions, hybrid events require the speaker to both pay attention to the local audience and the video conferencing chat tool, a significant multitasking challenge. Thus, the role of the session chair or moderator assumes additional importance.

Videoconferencing tools can often be run either in webinar mode or in interactive “peer” mode. In webinar mode, only selected panelists can speak and send video, while attendees remain anonymous and are often limited to posting questions via chat or a Q&A facility. Webinar mode may be appropriate for large conferences to minimize disruptions and allow the moderator or session chair to better structure the Q&A part, but is likely ill-suited for more interactive events.

5.1.4 Robots to the Rescue? In an intriguing development, a number of companies offer telepresence robots that can be remote-controlled, with video and audio capabilities. It seems unlikely that such robots would allow more than a handful of remote participants at a conference, but such robots may allow more interactive presentation and social engagement during smaller meetings. “Holographic” setups [1] that allow remote speakers to appear life-size and in a 3D-simulating rendering are also starting to appear. These technologies are still too immature to be part of a hybrid conference organizer’s repertoire, so we do not discuss them further.

5.2 Logistics, Finances, and Privacy

Logistics and financing these logistics are intertwined. A hybrid event is more challenging to plan, and possibly more expensive, than either a virtual or fully in-person event. For example, the number of on-site attendees may not be known until very close to the conference because of changing travel restrictions, e.g. during the pandemic. Historical attendance figures are likely to offer only limited guidance. As noted earlier, all but the smallest hybrid conferences are likely to incur additional costs compared to in-person-only or virtual events, primarily for on-site AV crews that manage cameras and sound, as well as licenses for video streaming or interaction tools. This is not new: even virtual conferences have

come to rely on external support to avoid overloading volunteers with tasks such as collecting author video recordings or creating recordings of interactive events.

Picking an appropriate registration fee for hybrid events is difficult, given the high fixed costs of most venues. The cost differential between virtual and fully in-person conferences has been staggering. For example, SIGCOMM 2020 and 2021 charged only \$40 for SIG members and \$15 for students, while SIGCOMM 2019 charged SIG members \$650 for early registration. If a hybrid conference were to mitigate risk by charging remote attendees the same fee as local attendees, the community would likely perceive this as unfair. One option is to delay the announcement of the remote attendance fee until after the early registration period for in-person attendance has closed. The fee for remote attendees should be set high enough to cover the additional cost of making content and interactions available online. Experience with virtual conferences such as PAM 2020 [7], SIGCOMM 2020 and 2021 indicate that the overall attendance, particularly by students, is significantly higher than for pre-COVID-19 years, indicating that a significant fraction of the remote attendees may continue to attend remotely, and thus provide additional income to the conference and sponsoring society, even as conferences transition from virtual to hybrid mode.

Balancing fees between local and remote attendees may turn out to be challenging for hybrid events: conference venues often need to be secured one to two years in advance, and often minimal consumption guarantees generally are part of contracts. Similarly, getting professional video production support will incur a base cost no matter if 10 or 1,000 participants are remote. Just as there was not much experience when moving from in-person to virtual events, we may also need some accumulated experience to determine venue sizes and cost factors when going hybrid. Some limited insights may be available from past conferences that provided setups for live streaming to allow passive remote participation (such as SIGCOMM 2012).

Traditionally, companies and funding agencies were asked to sponsor conferences so that either the attendance fees for students could be lowered or that the conference could offer travel grants to graduate students. If papers can be presented remotely and students can attend the conference at very low cost, the need for travel grants may appear less urgent to sponsors. At the same time, even fees perceived as low or modest may form obstacles for participation so that travel grant programs would need to be complemented by fee waiver grants to also support remote participation.

Hybrid conferences raise additional privacy concerns beyond both purely on-site and purely virtual events. For virtual conferences, attendees expect that just about everything except social events or individual interactions in poster sessions is recorded and made available to registered attendees, if not the public. While this choice needs to be made for any event that is being recorded, whether virtual, in-person or hybrid, it may not be as obvious to in-person or remote attendees what parts of the event will be preserved or made public. Organizers of hybrid conferences should inform attendees, e.g., during the registration process, which parts of the event are being recorded and made available to whom, and whether names are attached to text comments or questions. For example, on-site attendees may not realize that their questions may leave a permanent record and may be indexed by search engines.

Volume 52 Issue 2, April 2022

Organizers should also plan ahead whether Q&A audio or text chat content can be edited, whether by request of the author, the person asking a question or the conference organizers. For example, an audience member may want to avoid that a question that was unintentionally hostile become part of the public record. Such editing may not be feasible and attendees should be aware of the risks. Laws in some jurisdictions may further force collecting explicit consent.

Any conference with active remote participation needs to deal with potential disruption due to “Zoom bombers” [6] and needs to decide, for example, whether to pause the conference program if technical difficulties prevent remote attendees from participating. It may thus be advisable to allow for some headroom in planning (e.g., using sufficiently long breaks). Also, more interactive modes require additional staffing and volunteers, e.g., for monitoring of chat rooms for contributions coming from the remote participants as well as to assist instantaneously to cope with technical difficulties.

5.3 Structural and Operational Aspects

Virtual conference organizers have had the luxury of choosing time zones that maximize participation — or maybe just minimize the inconvenience for the organizing team. Virtual conferences have experimented with various ways to accommodate participants spread around the globe, such as offering an eastern hemisphere and western hemisphere repeat of the program, tried at SIGCOMM 2020, or spreading the program over more days, each with fewer hours of the programming schedule. Similarly, to reflect the geographic diversity of their communities, many larger conferences have been rotating among major regions, e.g., Europe, Asia and North America, for years, thus, largely deciding the time zone question.

Choosing an attendee-optimized or dual-session schedule is not feasible for hybrid events. Thus, remote participants will not suffer jet lag, but may have to put up with participating in a panel at 3 am in the morning. However, even as time zone issues cannot be avoided, holding key events such as keynotes at 14:30 UTC (10:30 am America/New York during daylight savings time) ensures that remote attendees, except in New Zealand and Australia, can participate during waking hours. Remote participants are likely to have to rely on video recordings, combined with asynchronous text chat tools, for sessions outside their temporal comfort zone.

For smaller events, onsite participants and organizers may need to show some flexibility to better integrate remote participants. For example, the plenary and break-out sessions could take place during the afternoon and evening hours to allow both European and North American remote participation (if those were the dominant ones), pushing local social events and personal time into the pre-lunch hours. Also, times for and lengths of breaks may be adjusted accordingly to make remote participation practical. If the participants and their respective time zones are known up front, those could be factored into the planning scheduling process.

For any hybrid event, organizers should make it easy for remote attendees to determine when sessions and other activities are taking place in their local time zone, without having to consult a separate timezone converter. For example, schedules can be posted as publicly accessible calendars or conference tools can allow viewers to select a personal timezone.

Instead of single hybrid conferences held in one location, the availability of a strong infrastructure for online participation also allows societies to consider organizing a multi-site or federated conference. Each conference would feature mostly its own program for local attendees and authors, possibly in the local language. National scientific societies organize each site-specific program (e.g., COMSNETS, SIGCOMM, APNET), could select “best papers” and keynotes shown to all venues, presented on behalf of the authors and possibly with simultaneous translation. SIGGRAPH Asia/Europe/US are examples. For non-local conference editions, papers could be presented by proxies and questions answered live, for instance. However, this strategy may also more permanently divide the community by geography.

6 OTHER RECOMMENDATIONS

So far we mainly considered events that follow a classical schedule and established interaction patterns between speakers, panelists, and the audience. We now present recommendations for some aspects of other types of events.

6.1 Interactive Workshops

Interactive workshops are small events with just a few tens of participants so that a meeting room could be reasonably small and the local participants would not necessarily require microphones to understand each other. Such less formal setting may give rise to lively discussions, which are easily held purely locally; to some extent this would also hold for purely virtual meetings following the usual social protocols, some minimal floor control mechanisms, and possibly a facilitator. For hybrid meetings, a moderator would be needed, as mentioned above, to mediate turn taking between local and remote participants. To establish a single discussion venue, the technical considerations of Section 5.1 apply.

Events that feature breakout groups will also need to handle establishing joint conversation spaces recursively for each subgroup. Hybrid subgroups would need to find quiet spots, ideally well-equipped meeting rooms with conferencing infrastructure, to allow for equal participation – and a moderator who ensures balance between local and remote participants. As a lower-effort alternative, a recent Dagstuhl seminar formed subgroups that consisted of either all local or all remote participants. This obviously constrains group composition and the topics a participant can contribute to.

Care should be taken, especially in such interactive settings, where more people may want to be active than in a conference setting, that we don’t end up with first class (local) and second class (remote) participants.

6.2 Brainstorming Sessions

Besides tools for audiovisual interaction, brainstorming sessions need tools for joint creation of ideas or structuring of topics, such as Miro, Etherpad, or Markdown, to be used by both local and remote participants. In the late 1990s, organizations such as the IETF experimented with digital whiteboards with limited success, but they might still work well for small-scale brainstorming sessions. Many primary and secondary schools have been using “smartboards” that also allow remote drawing for participants with tablets or pen-capable laptops. Floor control may need to be devised to decide

who is in charge of the whiteboard. Ideally, organizers would introduce the tools well in advance of the meeting to allow participants to become familiar with them. Of course, a video camera pointed to a physical whiteboard might be a good start with nearly zero overhead, albeit asymmetric participation.

6.3 Poster Sessions and Social Events

Conference events that allow participants to move about are particularly challenging to convert to hybrid format. These include poster sessions and social events.

For smaller poster sessions, remote presenters of posters to be shown at the in-person venue could appear on a large screen provided by the local organizers. Other remote participants could see a digital version and listen to the presenter, too. Alternatively, fully-online tools such as *gather.town* have become popular for poster sessions because they provide a reasonable approximation to an in-person poster session experience, but are currently not designed for sessions combining in-person and remote participants. Also, easily finding specific presenters or posters, or simply recognizing a person by face, remain unsolved. Some participants may also have privacy concerns, as it may be difficult to determine who has access to the data. Network latency may also be a barrier to immersive interaction.

Supporting social events at hybrid conferences is challenging. Organizers may well decide to organize separate events for online and in-person attendees, with online events similar to those now being tried for virtual events, including holding organized activities and “hallway” chats in spatially-oriented platforms such as *gather.town*. Naturally, in-person attendees can participate in such events from their laptop. Also, having a local participant assigned to a remote participant as some sort of caretaker may be considered, for example for events with small number of participants.

7 CHALLENGES AND OPPORTUNITIES

7.1 Challenges

We are still learning how to make hybrid conferences productive, effective, and offer roughly the same experience as an in-person conference — though this last goal will likely never be fully achieved. Below are some challenges that still face organizers of hybrid conferences.

First, experience has shown that it is difficult to foster creativity in virtual gatherings. Can we sustain creativity in hybrid modes, e.g., facilitating rapid back-and-forth discussions and mutual awareness?

Social meetings and hallway conversations are an important part of conferences, but not well supported in hybrid mode. Current virtual spaces, such as *gather.town*, do support a limited form of *ad hoc* gatherings, but they are not as effortless as meeting at the coffee table. Initially, until we have better tools, it is likely that on-site and remote attendees will need to find their own social interactions, rather than awkwardly trying to combine the two. But mutual awareness of in-person and virtual attendees may at least facilitate connecting with individuals one has met before.

Navigating hybrid meetings poses additional challenges. For example, it may be difficult to tell where groups of people are meeting or what topics are drawing attention.

During conversations that span local and remote participants, we need tools to manage activity and interactivity, and maintain continuity of the conversation beyond the initial set of participants. There is also a strong need for session control, by a human or by technology, that works well despite long delays to reach some participants, as well as and decision-making tools (such voting or IETF hum tools).

Means for social interactions during coffee-breaks or casual hallway exchanges will be needed to make the experience of a hybrid meeting be more real-life-like. Today’s technical solutions are not yet mature enough for convincing deployment, and current robot stand-ins or augmented reality type holograms of participants do not scale for larger groups of people or across different hosts and conference locations. In particular these challenges need to be addressed by further research and development.

7.2 Opportunities

Compared to purely online and passive hybrid conferences, semi-passive and true hybrid conferences allow for physical, in-person presence. Physical presence at conferences is valuable from the perspective of multiple sectors. Participants from industry can meet potential employees and learn of advances in the field. Participants from academia find physical presence critical for high-bandwidth learning and networking and recruiting students (or faculty). Participants from the government sector, especially those representing funding agencies, also find physical presence important to learn about the field and where additional economical incentives are needed. Physical presence also leads to multiple positive outcomes, for instance:

- *Face-to-face interaction*: Smaller gatherings allow participants to get a sense of which topics the research community is collectively moving towards.
- *Recruiting*: It is common for employers to send employees to recruit graduating doctoral students at conferences. This is typical for industry that especially runs dedicated job fairs at conferences to this end.
- *Forcing attendees to block off time*, with the benefit of getting energized by change of location and refreshed at a conference by change of the environment.
- *“Reward” vacation*: Travel to an attractive venue is a reward (especially for the student authors) for a paper being accepted and all the hard work it entails!

For these reasons, hybrid conferences, which allow physical presence, may be preferred to purely online conferences.

Hybrid conferences are also important from a financial perspective. Professional societies and professional organizations (such as ACM, IEEE, and IETF) are being hit with one or more of the following financial shocks: a loss of funds due to open access publishing, decline in membership, and declining conference revenues due to the move to online conference. Thus, they have an incentive to boost revenues using in-person conferences, which tend to bring in more revenue than online conferences.

Meanwhile, hybrid conferences are also more attractive for sponsors, compared to purely online conferences. Finally, researchers, both faculty and students also can typically access travel funds to travel to hybrid conferences. So, for these financial reasons, it is

expected that hybrid conferences would become more common in the future.

7.3 Diversity and Inclusion

Diversity has many different dimensions, such as including researchers from different geographical regions, from underrepresented groups, such as women in computer science, people with disabilities and researchers from institutions with limited financial resources. Hybrid conferences have the potential to allow a more diverse group of people to attend and participate in the technical and professional community. To allow opportunities for in-person participation and to equalize timezone burdens, we advocate locating the in-person component of the conference on different continents in a reasonably-predictable sequence. Many major conferences do this already⁴.

Hybrid conferences can be more inclusive by leveraging new technologies for both remote and in-person attendees. For instance, it is now possible to provide simultaneous translation for participants who speak no or limited English. Similarly, video recordings that can be rewound and slowed down, as well as automated text captions, greatly help non-native speakers. Naturally, text captions and text chat Q&A also facilitate participation by people who are Deaf. Finally, it may be possible to hire remote video interpreters for speakers of sign language, rather than having the sign language interpreter travel with the attendee.

One can even imagine having text-to-speech systems generate the audio content for a presentation from a script, although this may not be universally welcomed.

Although hybrid events, in general, have the potential to increase inclusion, they may create new divisions if in-person attendance is only possible for a small, privileged, subset of the community. For example, some faculty may restrict junior students to the remote option since funding for the in-person portion of the conference may be more difficult to obtain. Of course, industry may fund students to attend in person, motivated by the better recruiting opportunities.

Hybrid events may also generate social pressures not to travel to conferences. For example, researchers with young children may be pressured by family to attend remotely. Providing childcare at the venue may mitigate. However, it can be difficult to find on-site childcare even for hybrid conferences, especially for services that may need to be provided outside the normal work day.

Finally, some researchers may have access to better video production resources, making their presentation stand out by production values. As such, there may be a need to transfer travel money to video production costs and convince universities to offer professional recording services, building on their capacities available for remote teaching.

8 CONCLUSIONS

COVID-19, climate change, and the need to make scientific conferences more accessible, while balancing the undeniable need for person-to-person contact, will make hybrid conferences the most common conference mode going forward. We have presented a

⁴However, hybrid conferences may make this more difficult, e.g., since not all tools to support such events work in all geographies, such as the Google tools in China.

taxonomy of hybrid conferences, highlighted some decisions that organisers have to make when planning a hybrid conference, shown some key technical requirements and several key non-technical considerations.

ACKNOWLEDGMENTS

We are grateful to Schloss Dagstuhl for providing the setting to discuss this important topic at the seminar on “Climate Friendly Internet Research” [2] held in July 2021.

We specially like to thank Franziska Lichtblau, Daniel Karrenberg, Mirja Kühlewind, Colin Perkins, Mirjam Kühne, Quentin De Coninck, Jari Arkko, Cristel Pelsser, Sujata Banerjee, Amr Rizk, Michael Menth and Jürgen Schönwälder for their contributions at the breakout sessions that provided the initial input for this report.

This work was partly supported by the Volkswagenstiftung Niedersächsisches Vorab (Funding No. ZN3695).

- [1] AXIOS. 2021. “Holoportation” lets you beam yourself anywhere. <https://www.axios.com/holoportation-beam-portl-hologram-technology-3c9c1fd6-345f-4b5c-bff0-bc8964d482e4.html?stream=science> [Online; accessed 2021-12-14].
- [2] Vaibhav Bajpai, Oliver Hohlfeld, Jon Crowcroft, and Srinivasan Keshav. 2021. Towards Climate-Friendly Internet Research (Dagstuhl Seminar 21272). *Dagstuhl Reports* 11, 6 (2021), 14–37. <https://doi.org/10.4230/DagRep.11.6.14>
- [3] Stephen Casner and Stephen Deering. 1992. First IETF Internet Audiocast. *SIGCOMM Computer Communication Review* 22, 3 (jul 1992), 92–97. <https://doi.org/10.1145/142267.142338>
- [4] ACM Presidential Task Force. 2020. Virtual Conferences: A Guide to Best Practices. <https://www.acm.org/virtual-conferences> [Online; accessed 2021-12-14].
- [5] Oliver Hohlfeld, Dennis Guse, and Katrien De Moor. 2021. A Questionnaire to Assess Virtual Conference Participation Experience. In *IEEE QoMEX*.
- [6] Chen Ling, Utkucan Balci, Jeremy Blackburn, and Gianluca Stringhini. 2021. A First Look at Zoombombing. In *42nd IEEE Symposium on Security and Privacy, SP 2021, San Francisco, CA, USA, 24-27 May 2021*. IEEE, 1452–1467. <https://doi.org/10.1109/SP40001.2021.00061>
- [7] Chris Misa, Dennis Guse, Oliver Hohlfeld, Ramakrishnan Durairajan, Anna Sperotto, Alberto Dainotti, and Reza Rejaie. 2020. Lessons Learned Organizing the PAM 2020 Virtual Conference. *SIGCOMM Computer Communication Review* 50 (July 2020). Issue 3.
- [8] Foundation myclimate. 2021. Calculate the Carbon Footprint of your Flight. https://co2.myclimate.org/en/flight_calculators/new [Online; accessed 2021-12-14].
- [9] Benjamin C. Pierce, Michael Hicks, Crista Lopes, and Jens Palsberg. 2020. Conferences in an Era of Expensive Carbon. *Commun. ACM* 63, 3 (2020), 35–37. <https://doi.org/10.1145/3380445>
- [10] Alexander Raake, Markus Fiedler, Katrin Schoenberg, Katrien De Moor, and Nicola Döring. 2022. Technological Factors Influencing Videoconferencing and Zoom Fatigue. arXiv:2202.01740 [cs.HC]
- [11] Hannah Ritchie. 2020. Where in the World do People emit the most CO2? <https://ourworldindata.org/per-capita-co2> [Online; accessed 2021-12-14].