

# Networks and Autonomous Systems Project Proposal

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## Title: Ad Hoc Network Integration For Immersive Performances (ANIFIP)

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Subtitle: Leveraging a Robust Hard Real-Time Ad Hoc Network Infrastructure to Create Immersive Live Performances

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### Abstract:

The integration of technology in live music performances has significantly evolved, offering opportunities for enhanced audience experiences. Nonetheless, the main players in this area (e.g. [Xyloband](#), [PixMob](#)) control their lighting products using Infrared (IR) or Radio Frequency (RF), which poses an opportunity for emerging and disruptive solutions. Our project aims to leverage the power of ad hoc networks to revolutionize live performances through various innovative applications. By synchronizing audio, visual effects, lighting, audience interaction, and multi-point video streaming, we seek to create immersive and captivating experiences for both performers and audiences alike. For the purpose of this course, we will focus on developing a Proof of Concept (PoC) capable of demonstrating the feasibility and basic functionality of each component within a controlled environment. Our PoC addresses the challenge of based in one single input (which in the future could be a MIDI signal) actuate in several actuators such as LEDs and Image/Video stream by changing the color or image, respectively.

### Project Overview:

Our project encompasses four main components, each targeting a distinct aspect of live performance enhancement through ad hoc network integration:

1. **Multi-Channel Audio Synchronization:** Creating a surround sound experience by synchronizing audio signals among multiple speakers, amplifiers, and musical instruments.
2. **Interactive Visual Effects and Lighting Control:** Synchronizing visual effects, lighting, and stage effects with live performances to engage and captivate the audience visually.
3. **Audience Interaction and Participation:** Facilitating audience interaction and participation through real-time feedback, voting, and interactive features via a mobile app or other interface connected to the ad hoc network.
4. **Multi-Point Video Streaming and Projection Mapping:** Enabling multi-point video streaming and projection mapping to synchronize visual content with live performances, enhancing the visual experience for the audience.

Our project distinguishes itself from existing solutions controlled by IR or RF technologies by harnessing the flexibility and scalability of ad hoc networks. Unlike traditional methods which often rely on line-of-sight communication and limited range, our approach offers a more robust and dynamic platform for synchronizing audio, visual effects, and audience interaction seamlessly. By leveraging ad hoc networks, we can overcome the constraints of traditional control methods, allowing for greater flexibility in performance setups and enhancing the overall immersive experience for both performers and audiences. This innovative approach not only opens new avenues for creative expression but also provides opportunities for real-time adaptation and customization, ultimately redefining the landscape of live music performances.

### Proof of Concept Focus:

For our PoC, we propose to develop an ad hoc network capable of receiving commands from a central controller and propagating these commands to all nodes within the network. Each node will be tasked with performing specific actions based on the received command, showcasing the versatility and functionality of the ad hoc network in synchronizing various elements of live performances.

The successful implementation of the PoC will be validated through a series of demonstrations showcasing the synchronization capabilities of the ad hoc network in a controlled environment. We will measure and analyze the latency of command propagation and node response times to ensure that our system meets the stringent requirements of hard real-time applications.

### Key Components and Functionality:

1. **Ad Hoc Network Infrastructure** We will establish an ad hoc network infrastructure using off-the-shelf hardware and software solutions capable of facilitating communication between multiple nodes. This network will serve as the backbone for transmitting commands from the central controller to all connected nodes in real-time.
2. **Command Propagation** Upon receiving a command from the central controller, the ad hoc network will propagate this command to all nodes within the network with minimal latency. This ensures that all nodes are synchronized and respond simultaneously to the instructions provided by the central controller.
3. **Node Actions and Functionality** Each node within the ad hoc network will be assigned specific tasks based on their capabilities. For instance, nodes dedicated to controlling lights will be programmed to turn on LEDs or change their color in accordance with the received command. Similarly, nodes responsible for controlling projections will be tasked with changing the displayed image.
4. **Latency Optimization** Given the hard real-time nature of the application, minimizing latency is paramount to ensuring seamless synchronization between audio, visual effects, and audience interaction. To achieve this, we will implement optimization techniques at the software level, prioritizing low-latency communication protocols and efficient data transmission methods. We could also implement optimization techniques at hardware level, but that is out of scope from this course and masters degree.

### Conclusion:

Through the development of this PoC, we aim to demonstrate the feasibility and potential of ad hoc networks in revolutionizing live performances by enabling seamless synchronization of audio, visual effects, and audience interaction. While our focus will be on achieving basic functionality within the constraints of the course, the PoC will serve as a stepping stone towards realizing the full vision of our project in future implementations.

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### Cool Companies Related to this Area

- [Loopd](#) Loopd is a combination of a Bluetooth enabled badge and a mobile app which helps to drive attendee engagement by providing real-time event data. It allows to check how many people are attending an event, who all are attending, for what duration, identifying attendees at each hub in live-time. It allows attendees to easily connect with each other, exchange contact information, collect information about products. Loopd app gives relational analytics based on the information collected by Loopd badge. Charges a subscription fee between \$3k-\$6k separately for analytics and app. Customers include SXSW, Panasonic,

Box, Xero among others. Has won "Product of The Year" at Wearable Tech Expo 2015, Global Event Technology Startup of the Year at IMEX pitch 2015. ([Source](#))

- **Bizzabo's Klik** Klik provides smart device-based networking solutions for events. Products include a wristband and a badge that allows attendees to connect with others and exchange information. The devices use a Bluetooth wireless chip that connects to the cloud-based backend platform. Features include guest list management, scheduling, floor plans, gamification, and real-time engagement reporting & analytics. Customers include TEDxMontreal, ACEE Symposium 2016, DockerCon 2016, BAI Beacon 2016, NBC Upfront 2016, PEPSICO among others.
- **Xylobands** The Xyloband is a wristband developed by RB Concepts Ltd, containing light-emitting diodes (LEDs) and a radio frequency receiver. Typically utilized in live entertainment settings, it was created by entrepreneur Clive Banks and inventor Jason Regler. The wristband's lights can be controlled through software, which sends signals instructing it to light up or blink. Available in various colors, the wristbands are made of thick fabric with LEDs embedded within. A radio receiver within a plastic case on the band captures signals from a controller, which can be a handheld remote or a laptop-linked transmitter with ranges of up to 250 or 300 meters, respectively. Operators can program all or select wristbands to flash at specific intervals or moments. ([Source](#))
- **PixMob** PixMob develops wearable LED devices like bands, pendants etc. The device is worn by the audience which can be controlled from a central unit to create additional lighting effects. The solution uses infrared to send commands to the LED devices. PixMob allows the user to send different instructions to different devices simultaneously. The company has worked with a number of major artists, sports organisations like Tiesto, NBA, etc. ([Source](#))
- **Crowdled** CrowdLED is the leading provider of remote-controlled LED wristbands for events, with extensive experience spanning thousands of events worldwide. Our wristbands create immersive light shows and enhance the audience experience, while also being environmentally sustainable. We recycle all of our products to minimize waste and carbon emissions. CrowdLED offers flexible solutions, with both dry-hire and turnkey options available. We have the expertise and technology to make your event unforgettable while also being environmentally responsible. ([Source](#))

#### Interesting Papers:

- Hard real-time communication for mobile ad hoc networks ([link](#))
- Mobile wireless ad-hoc network routing protocols comparison for real-time military application ([link](#))
- Real-time video over wireless ad-hoc networks ([link](#))
- Cost-effective live video streaming for internet of connected vehicles using heterogeneous networks ([link](#))
- An optimized link state routing protocol for real-time application over Vehicular Ad-hoc Network ([link](#))
- Design and Implementation of Real-Time Video Transmission on Ad Hoc Network ([link](#))