Banner: An Image Sensor Reconfiguration Framework for Seamless Resolution-based Tradeoffs

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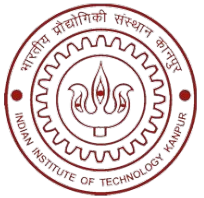
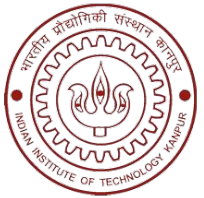


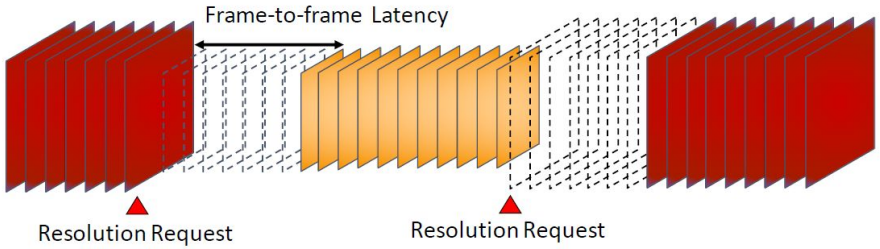
Introduction

- Banner is a media framework designed to make camera resolution changes smooth and quick.
- High-resolution video drains battery quickly in mobile devices, but high detail isn't always necessary.
- Banner's goal is to enable dynamic resolution switching to save energy while maintaining video quality.
- Banner eliminates delays that typically disrupt video during resolution changes.



Problem Statement

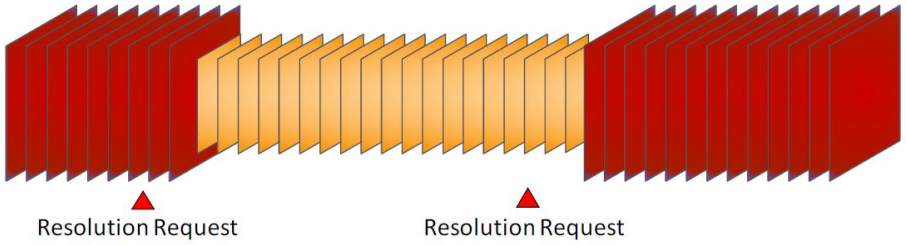
- High-resolution video capture provides detail but uses a lot of energy.
- Switching camera resolution in current systems causes up to 280 ms delay.
- This delay results in frame drops and reduces real-time video performance.
- The delay blocks potential energy savings by preventing flexible resolution changes.



(a) In legacy systems, any change in sensor resolution leads to a substantial pause in frame delivery.

Solution: Banner Framework

- Banner allows fast, seamless resolution changes without interruptions.
- Uses two main techniques to speed up changes: parallel reconfiguration and format-oblivious memory management.
- Parallel reconfiguration keeps the camera capturing while resolution changes in the background.
- Format-oblivious memory management avoids memory resets, speeding up the switch.Banner eliminates frame drops and reduces reconfiguration time by over 50%.

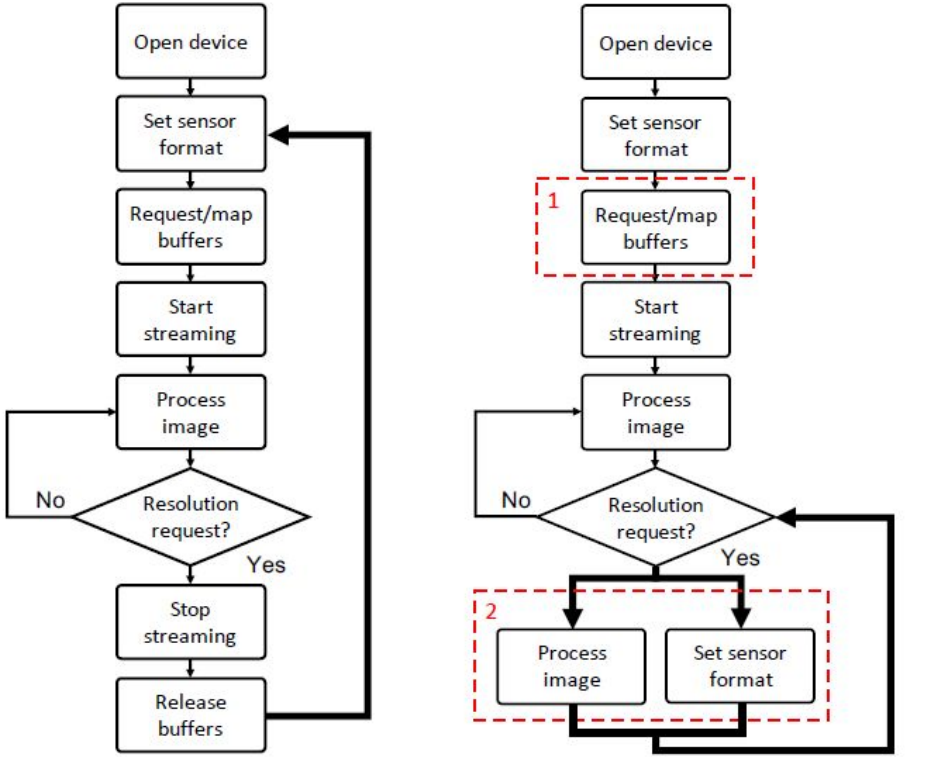


(b) Banner completely removes frame-to-frame latency for reconfiguring sensor resolution.

Design of Banner

- **Purpose**:
  Banner enables fast, smooth resolution changes in the V4L2 framework without frame drops.
- **Techniques**:
  - Parallel Reconfiguration
  - Format-Oblivious Memory
- **Process**:
  Skips unnecessary steps (e.g., stopping/restarting streams).New resolution frames appear immediately after processing frames from the previous resolution.
- **Outcome**:
  Seamless, continuous multi-resolution video capture, reducing reconfiguration delay by over 50%.

Figure 4: In Banner, most of the sequential procedures are avoided for reconfiguring sensor resolution.



(a) Resolution reconfiguration in legacy V4L2

(b) Resolution reconfiguration in Banner

Parallel Reconfiguration

- In current systems, resolution changes interrupt video capture.
- Parallel reconfiguration in Banner allows changes in the background without stopping the video stream.
- Resolution switches happen while the camera keeps capturing video.
- Result: No visible pauses, so the video stream remains smooth.

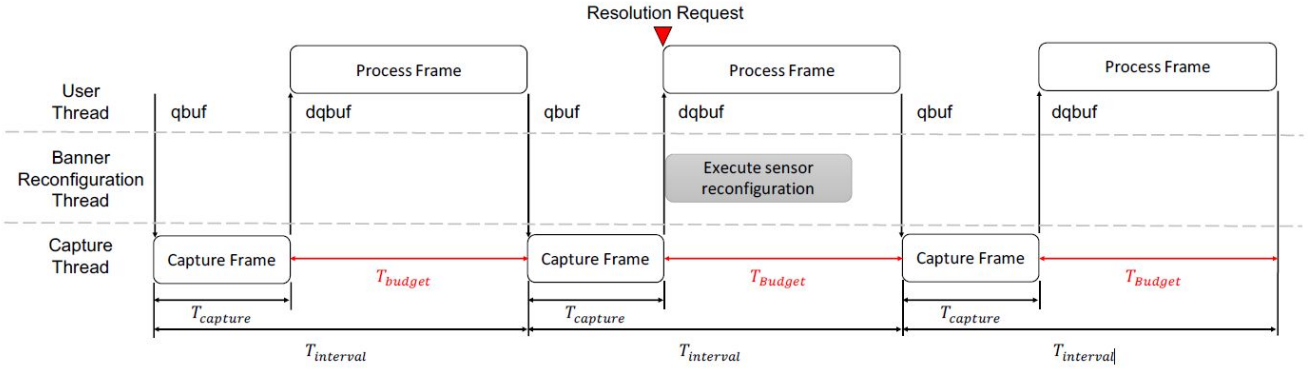


Figure 5: Banner reconfigures sensor resolution in parallel with application processing frames in the reconfiguration timing budget (a function of frame interval and capture time) such that reconfiguration latency can be hidden.

Format-Oblivious Memory Management

- Typically, each resolution change needs memory to be reset, causing delays. Banner uses a flexible memory setup that works across different resolutions without resetting.
- This setup avoids repeated memory allocation, speeding up resolution switching. Result: Faster, smoother transitions between resolutions.

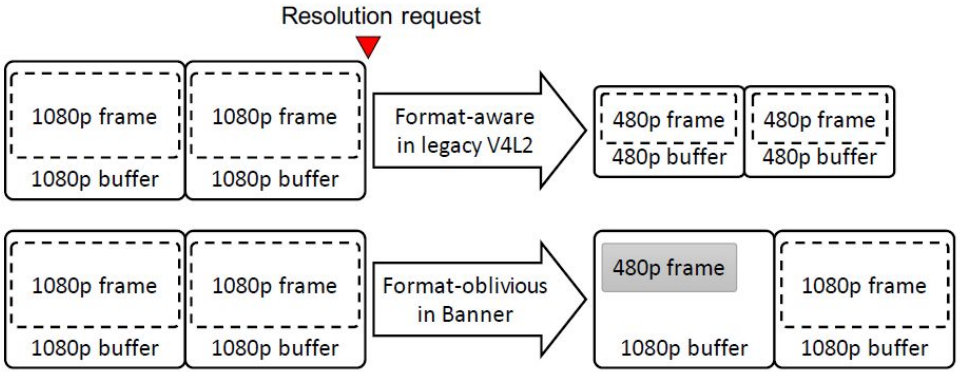


Figure 6: After a resolution request, format-oblivious memory management in Banner reuses buffers previously allocated and stores newly configured frames, despite potential format mismatch.

Evaluation Results

- Frame-to-Frame Latency: Reduced from 226 ms to 33 ms.
- End-to-End Latency: Reduced by 54%, from 226 ms to 105 ms.
- Power Savings: Up to 49% reduction when switching to lower resolutions.
- Banner achieved seamless, fast resolution switching in all workloads.

Challenges and Future Work

- Limitations:
  - Integration with Android requires driver modifications.
- Future Directions:
  - Optimized memory management for frequent resolution changes.
  - Advanced algorithms for dynamic resolution selection.
- Goal:
  - To further improve Banner's efficiency and expand compatibility

Conclusion

- Banner boosts mobile vision systems by making them faster and more energy-efficient.
- Enables smooth, real-time resolution switching without interruptions or frame drops.
- Key Benefits:
  - •Cuts power use, improving battery life for continuous vision tasks.
  - •Balances high image quality with energy efficiency, adapting to task needs.
- Impact: Unlocks potential for energy savings and improved performance in mobile devices.

THANK YOU