Reducing Task Completion Time in Mobile Offloading Systems through Online Adaptive Local Restart

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Mobile cloud computing architecture.
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Offloading system $\implies$ Advantages:

Shorten execution time + Reduce energy consumption
Mobile Offloading System

- Mobile cloud computing architecture.
- Offloading system $\Rightarrow$ **Advantages**: Shorten execution time + Reduce energy consumption
- Failures or delays can happen in the network and in the cloud server.
- how long should one wait and when to restart locally?
Program engine and decision algorithm run on mobile device, that interacts with cloud server
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Offloading uses copy of algorithm in the server
Offloading system architecture

- Program engine and decision algorithm run on mobile device, that interacts with cloud server
- Offloading uses copy of algorithm in the server
- Local restart will not offload but executes in mobile device
- Online decision making needs adaptive timeout.
The test bed

- **Mobile Devices**: Samsung GT-S7568, Android 4.0;
- **Wireless Network**: 54M/s WiFi; The route passes 12 hops and the round-trip time is 82ms.
- **Server**: Server with 4 cores (Intel Xeon CPU E5649 2.53 GHz)
The test bed

Mobile Devices: Samsung GT-S7568, Android 4.0;
Wireless Network: 54M/s WiFi The route passes 12 hops and the round-trip time is 82ms.
Server: Server with 4 cores (Intel Xeon CPU E5649 2.53 GHz)
Sample Application: Optical Character Recognition (OCR)
The distribution of the sample values is not identical across time.

OCT: Offloading Task completion time
The distribution of the sample values is not identical across time.

Local computation is usually stable, with very few outliers.  
LCT: Local Executed Task completion time
Bad network condition: the curve has an approximately constant slope of $-2 \rightarrow$ a heavy tail.
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Deteriorated network condition: the tail has an exponential decay for long task completion times $\rightarrow$ heavy tail is not clear.
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Normal network condition: the decrease of the tail is steep $\rightarrow$ no heavy tail.
Bad network condition: the curve has an approximately constant slope of $-2 \rightarrow$ a heavy tail.

Deteriorated network condition: the tail has an exponential decay for long task completion times $\rightarrow$ heavy tail is not clear.

Normal network condition: the decrease of the tail is steep $\rightarrow$ no heavy tail.

Local completion: the tail is almost infinite $\rightarrow$ no heavy tail.
Distribution Fitting Results

- Use Hyperstar for distribution fitting
- Task completion times has a lower threshold $T_{min}^o$
- Shift histogram to the left, $f_o(t) = f'_o(t - T_{min}^o)$ to avoid zero density at the origin
- $f'_o(t)$ is the PH fitting result
Restart Condition

- \( E[T] < E[T - \tau | T > \tau] \)
  - \( T \): task completion time
  - \( \tau \): restart timeout

Expected completion time less than expected remaining time until completion
Restart Condition

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Expected completion time less than expected remaining time until completion

For one local restart

\[
F(t) = \begin{cases} 
F_o(t) & (0 \leq t < \tau) \\
1 - (1 - F_o(\tau))(1 - F_l(t - \tau)) & (\tau \leq t)
\end{cases}
\]

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\]

\( f(t) \) and \( F(t) \) are the density and cumulative distribution function
Local Restart Condition

- If $E[T] < E[T_o]$, restart is beneficial.

$$E[T_l] < \frac{\int_\tau^\infty t f_o(t) dt}{1 - F_o(\tau)} - \tau$$

$$E[T_l] < \frac{\int_{\tau - T_{o min}}^\infty t f'_o(t) dt}{1 - F'_o(\tau - T_{o min})} - (\tau - T_{o min})$$

$$g(\delta) = \frac{\int_\delta^\infty t f'_o(t) dt}{1 - F'_o(\delta)} - \delta$$

$$(\delta = \tau - T_{o min})$$
Optimal Restart Timeout

\[ g(\delta) > E[T_l], \text{ the local restart is useful} \]
Optimal Restart Timeout

- $g(\delta) > E[T_i]$, the local restart is useful
- The optimal timeout is found when $E[T]$ is minimal.
Dynamic Restart Scheme

$g(\delta)$ and $E[T]$ are estimated from the histogram
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Dynamic Restart Scheme

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Dynamic Restart Scheme

- \( g(\delta) \) and \( E[T] \) are estimated from the histogram
- Case 1: large items in outlier bucket, case 2: small items create new bucket, case 3: medium items go into existing buckets.
Dynamic Restart Scheme

- $g(\delta)$ and $E[T]$ are estimated from the histogram.
- Case 1: large items in outlier bucket, case 2: small items create new bucket, case 3: medium items go into existing buckets.
- Dynamic histogram uses partial flush.
Evaluation of the Dynamic Restart

- When $\hat{g}(\delta)_{max} > T_l$ local restarts happen
Evaluation of the Dynamic Restart

When $\hat{g}(\delta)_{max} > T_l$ local restarts happen.

At certain times (evening), dynamic local restart can increase the throughput.
Conclusions

- Mobile offloading is not always beneficial
  - Experiments illustrate the impact of network delays
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  - Dynamic histogram adaptively tracks variation of network quality
  - Use dynamic histogram for restart decision and timeout.
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  - Experiments illustrate the impact of network delays
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- Dynamic local restart scheme
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  - Use dynamic histogram for restart decision and timeout.
- General solution for other applications?
- Many restarts, mixed local and remote
Thank you.