周报告

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本周进展

- 根据之前的算法问题，演算及优化想法，提出优化后可靠性模型
- 对提出的模型进行基本的分布式应用实验

■满足可靠性目标的资源最小化研究

➢调度策略优化

$$\text{满足可靠性目标的资源最小化} \xrightarrow{\text{拆分为两个子问题}} \left\{\begin{array}{l}\text{满足功能的可靠性约束}\\ \text{最小化资源开销成本}\end{array}\right.$$

$$cost(n_i, u_k) = w_{i,k} \times \gamma_k + \sum_{n_x \in pred(n_i)} c'_{x,i} \times \gamma_{\mathrm{comm}}$$

该策略的关键在于任务可靠性目标的模型，即如何将功能的可靠性目标$R_{goal}(G)$转换成任务的可靠性目标。

■满足可靠性目标的资源最小化研究

➢调度策略优化

对于任何一个汽车电子分布式功能G，给定可靠性目标$R_{goal}(G)$，在满足其目标下，将任务调度至资源成本最小的处理器。

任务的可靠性目标模型

MaxRe

$$R_{\text{goal}}(n_1) = \sqrt[|N|]{R_{\text{goal}}(G)}$$

RR

$$R_{\text{goal}}(n_{seq(j)}) = \sqrt[|N|-j+1]{\frac{R_{\text{goal}}(G)}{\prod_{x=1}^{j-1} R(n_x)}}.$$

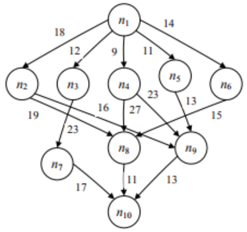
传统可靠性目标模型未考虑前驱及后驱任务对当前任务可靠性目标的影响

MRCRG

$$R_{\text{goal}}(n_{seq(j)}) = R_{\text{goal}}(G) \Big/ \left(\prod_{x=1}^{j-1} R(n_{seq(x)}, u_{proc(seq(x))}) \times \prod_{y=j+1}^{|N|} R_{\max}(n_{seq(y)}) \right)$$

考虑前驱集及后驱集，但后驱集任务可靠性预设值过于悲观

■满足可靠性目标的资源最小化研究



➢调度策略优化——任务可靠性模型修订

1. 假定利用MaxRe算法的方式对后驱任务可靠性预设值，通过实验，使得目标过高无法调度。
则定义一个可靠性下限值lower bound

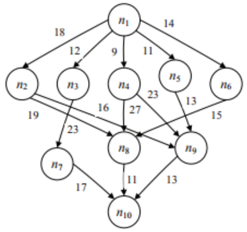
$$R_{lb\_req}(n_{seq(y)}) = \sqrt[|N|]{R_{goal}(G)}$$

n_i	$R(n_i,u_1)$	$R(n_i,u_2)$	$R(n_i,u_3)$	$R_{goal}(n_i)$
n_1	0.9930	0.9968	0.9919	0.9949
n_3	0.9945	0.9974	0.9830	0.9980
n_4	0.9935	0.9984	0.9848	
n_2	0.9935	0.9962	0.9839	
n_5	0.9940	0.9974	0.9910	
n_6	0.9935	0.9968	0.9919	
n_9	0.9910	0.9976	0.9822	
n_7	0.9965	0.9970	0.9901	
n_8	0.9975	0.9978	0.9875	
n_{10}	0.9896	0.9986	0.9857	

2. MRCRG算法以可靠性最大值对后驱任务预设可靠性值，过于悲观
则将每个任务可靠性最大值定义为可靠性上限值upper bound

$$R_{up\_req}(n_{seq(y)}) = R_{max}(n_{seq(y)})$$

■满足可靠性目标的资源最小化研究



➢调度策略优化——任务可靠性模型修订

3. 提出可靠性预设值的几何平均值计算模型，对于未调度任务的可靠性，预设为上限值与下限值的几何平均值

$$\begin{aligned}&R_{seq(j)}(G)\\&=\prod_{x=1}^{j-1} R\left(n_{seq(x)}, u_{proc(seq(x))}\right)\\&\times R\left(n_{seq(j)}, u_{proc(seq(j))}\right)\\&\times \prod_{y=j+1}^{|N|} \sqrt{R_{lb\_req}\left(n_{seq(y)}\right) \times R_{up\_req}\left(n_{seq(y)}\right)}\\&\geq R_{goal}(G)\end{aligned}$$

⇨

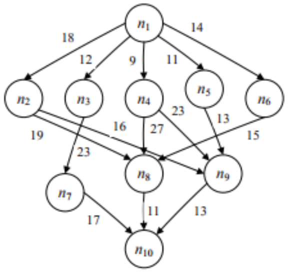
$$\begin{aligned}&R_{goal}\left(n_{seq(j)}\right)\\&=R_{goal}(G)\\&/\left(\prod_{x=1}^{j-1} R\left(n_{seq(x)}, u_{proc(seq(x))}\right)\right.\\&\left.\times \prod_{y=j+1}^{|N|} \sqrt{R_{lb\_req}\left(n_{seq(y)}\right) \times R_{up\_req}\left(n_{seq(y)}\right)}\right)\end{aligned}$$

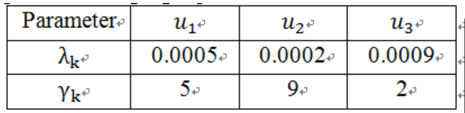
同时，为了严谨性，对下限值进行修正

$$\begin{aligned}&R_{lb\_req}\left(n_{seq(y)}\right)\\&=min\left(R_{lb\_req}\left(n_{seq(y)}\right), R_{max}\left(n_{seq(y)}\right)\right)\end{aligned}$$

■满足可靠性目标的资源最小化研究

➢调度策略优化——任务可靠性模型修订



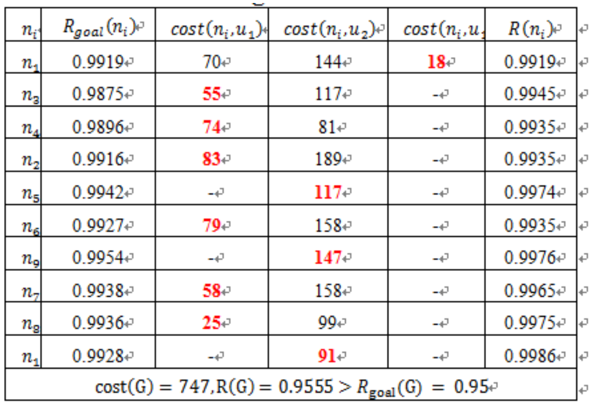


Parameter	u_1	u_2	u_3
λ_k	0.0005	0.0002	0.0009
γ_k	5	9	2

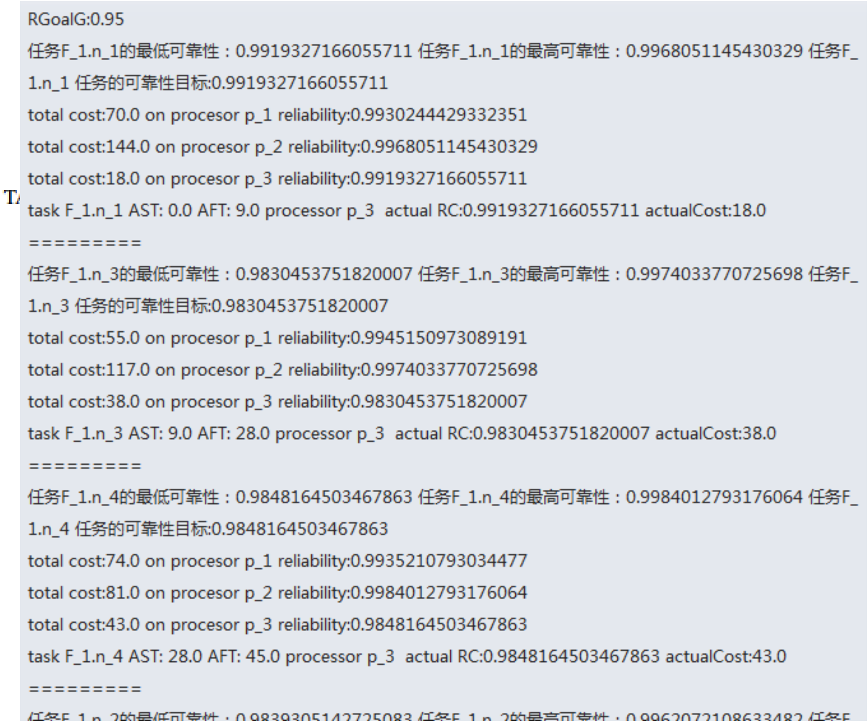
应用模型及处理器参数

实验结果——目前只对经典的分布式应用进行了实验

修改后的模型



n_i	$R_{goal}(n_i)$	$cost(n_i,u_1)$	$cost(n_i,u_2)$	$cost(n_i,u$	$R(n_i)$
n_1	0.9919	70	144	**18**	0.9919
n_3	0.9875	**55**	117	-	0.9945
n_4	0.9896	**74**	81	-	0.9935
n_2	0.9916	**83**	189	-	0.9935
n_5	0.9942	-	**117**	-	0.9974
n_6	0.9927	**79**	158	-	0.9935
n_9	0.9954	-	**147**	-	0.9976
n_7	0.9938	**58**	158	-	0.9965
n_8	0.9936	**25**	99	-	0.9975
n_1	0.9928	-	**91**	-	0.9986
$\mathrm{cost(G)} = 747, \mathrm{R(G)} = 0.9555 > R_{\mathrm{goal}}(\mathrm{G}) = 0.95$					



```
RGoalG:0.95
任务F_1.n_1的最低可靠性：0.9919327166055711 任务F_1.n_1的最高可靠性：0.9968051145430329 任务F_
1.n_1 任务的可靠性目标:0.9919327166055711
total cost:70.0 on procesor p_1 reliability:0.9930244429332351
total cost:144.0 on procesor p_2 reliability:0.9968051145430329
total cost:18.0 on procesor p_3 reliability:0.9919327166055711
task F_1.n_1 AST: 0.0 AFT: 9.0 processor p_3  actual RC:0.9919327166055711 actualCost:18.0
=========
任务F_1.n_3的最低可靠性：0.9830453751820007 任务F_1.n_3的最高可靠性：0.9974033770725698 任务F_
1.n_3 任务的可靠性目标:0.9830453751820007
total cost:55.0 on procesor p_1 reliability:0.9945150973089191
total cost:117.0 on procesor p_2 reliability:0.9974033770725698
total cost:38.0 on procesor p_3 reliability:0.9830453751820007
task F_1.n_3 AST: 9.0 AFT: 28.0 processor p_3  actual RC:0.9830453751820007 actualCost:38.0
=========
任务F_1.n_4的最低可靠性：0.9848164503467863 任务F_1.n_4的最高可靠性：0.9984012793176064 任务F_
1.n_4 任务的可靠性目标:0.9848164503467863
total cost:74.0 on procesor p_1 reliability:0.9935210793034477
total cost:81.0 on procesor p_2 reliability:0.9984012793176064
total cost:43.0 on procesor p_3 reliability:0.9848164503467863
task F_1.n_4 AST: 28.0 AFT: 45.0 processor p_3  actual RC:0.9848164503467863 actualCost:43.0
=========
任务F_1.n_2的最低可靠性：0.9839305142725083 任务F_1.n_2的最高可靠性：0.9962072108633482 任务F
```

■满足可靠性目标的资源最小化

➢调度策略优化——创新点

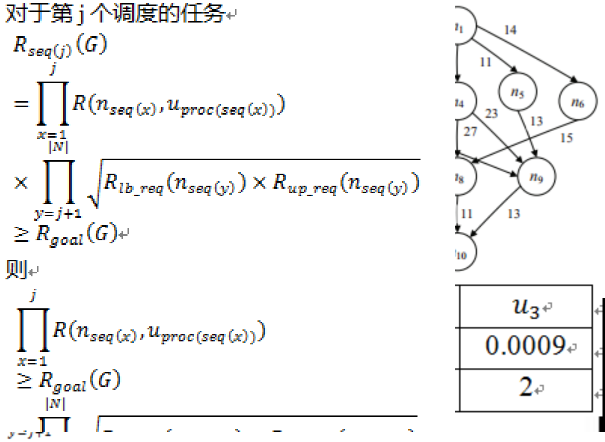
1. 改进MRCRG在计算当前任务可靠性时以可靠性最大值为后驱任务的预设值的悲观性

2. 将经典MaxRe算法的计算方法结合，并以完善

$$R_{lb\_req}(n_{seq(y)}) = min\left(R_{lb\_req}(n_{seq(y)}), R_{max}(n_{seq(y)}) \right)$$

3. 数学归纳法证明调度可行性（已证）

4. 当前实验证明该算法能满足应用可靠性目标，且能较于MRCRG算法较多的减少资源消耗成本（实验尚未完成）



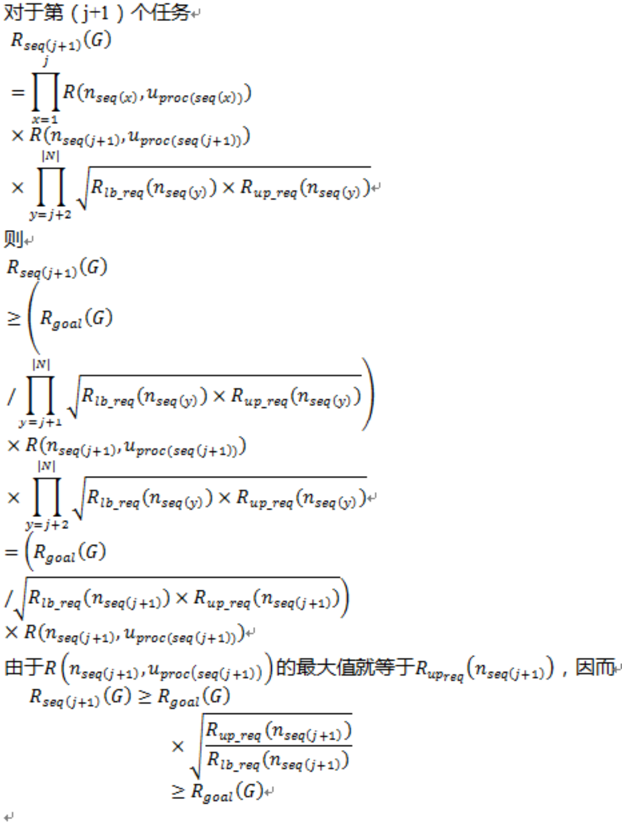
对于第 j 个调度的任务

$$R_{seq(j)}(G) = \prod_{x=1}^{j} R(n_{seq(x)}, u_{proc(seq(x))}) \times \prod_{y=j+1}^{|N|} \sqrt{R_{lb\_req}(n_{seq(y)}) \times R_{up\_req}(n_{seq(y)})} \geq R_{goal}(G)$$

则

$$\prod_{x=1}^{j} R(n_{seq(x)}, u_{proc(seq(x))}) \geq R_{goal}(G)$$

u_3
0.0009
2



对于第（j+1）个任务

$$R_{seq(j+1)}(G) = \prod_{x=1}^{j} R(n_{seq(x)}, u_{proc(seq(x))}) \times R(n_{seq(j+1)}, u_{proc(seq(j+1))}) \times \prod_{y=j+2}^{|N|} \sqrt{R_{lb\_req}(n_{seq(y)}) \times R_{up\_req}(n_{seq(y)})}$$

则

$$R_{seq(j+1)}(G) \geq \left(R_{goal}(G) / \prod_{y=j+1}^{|N|} \sqrt{R_{lb\_req}(n_{seq(y)}) \times R_{up\_req}(n_{seq(y)})} \right) \times R(n_{seq(j+1)}, u_{proc(seq(j+1))}) \times \prod_{y=j+2}^{|N|} \sqrt{R_{lb\_req}(n_{seq(y)}) \times R_{up\_req}(n_{seq(y)})}$$

$$= \left(R_{goal}(G) / \sqrt{R_{lb\_req}(n_{seq(j+1)}) \times R_{up\_req}(n_{seq(j+1)})} \right) \times R(n_{seq(j+1)}, u_{proc(seq(j+1))})$$

由于$R\left(n_{seq(j+1)}, u_{proc(seq(j+1))}\right)$的最大值就等于$R_{upreq}\left(n_{seq(j+1)}\right)$，因而

$$R_{seq(j+1)}(G) \geq R_{goal}(G) \times \sqrt{\frac{R_{up\_req}(n_{seq(j+1)})}{R_{lb\_req}(n_{seq(j+1)})}} \geq R_{goal}(G)$$

下一步计划

- 边写论文，边完成高斯实验与真实基准汽车实验等
- 汽车可靠性专刊

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Topics of interest include but are not limited to:

- Functional Safety and Security
  - Functional safety and security in the automotive systems
  - Automotive functional safely standards and certification
  - Reuse of test infrastructure in automated driving solutions
  - System level test for safety critical systems
  - Hardware/Software architectures for functional safety and security
- Dependability
  - Multi-layer dependability evaluation
  - Verification and validation of automotive systems
  - Reliability challenges of autonomous driving and e-mobility
  - Aging effects on automotive electronics
  - Power-up, power-down and in-system periodic test
- Testability
  - Built-In Self-Test (BIST and SBST) in automotive systems
  - Functional and structural test generation for automotive systems
  - Automotive quality volume manufacturing test and minimizing DPPM
  - Life cycle test cost minimization in safety critical systems